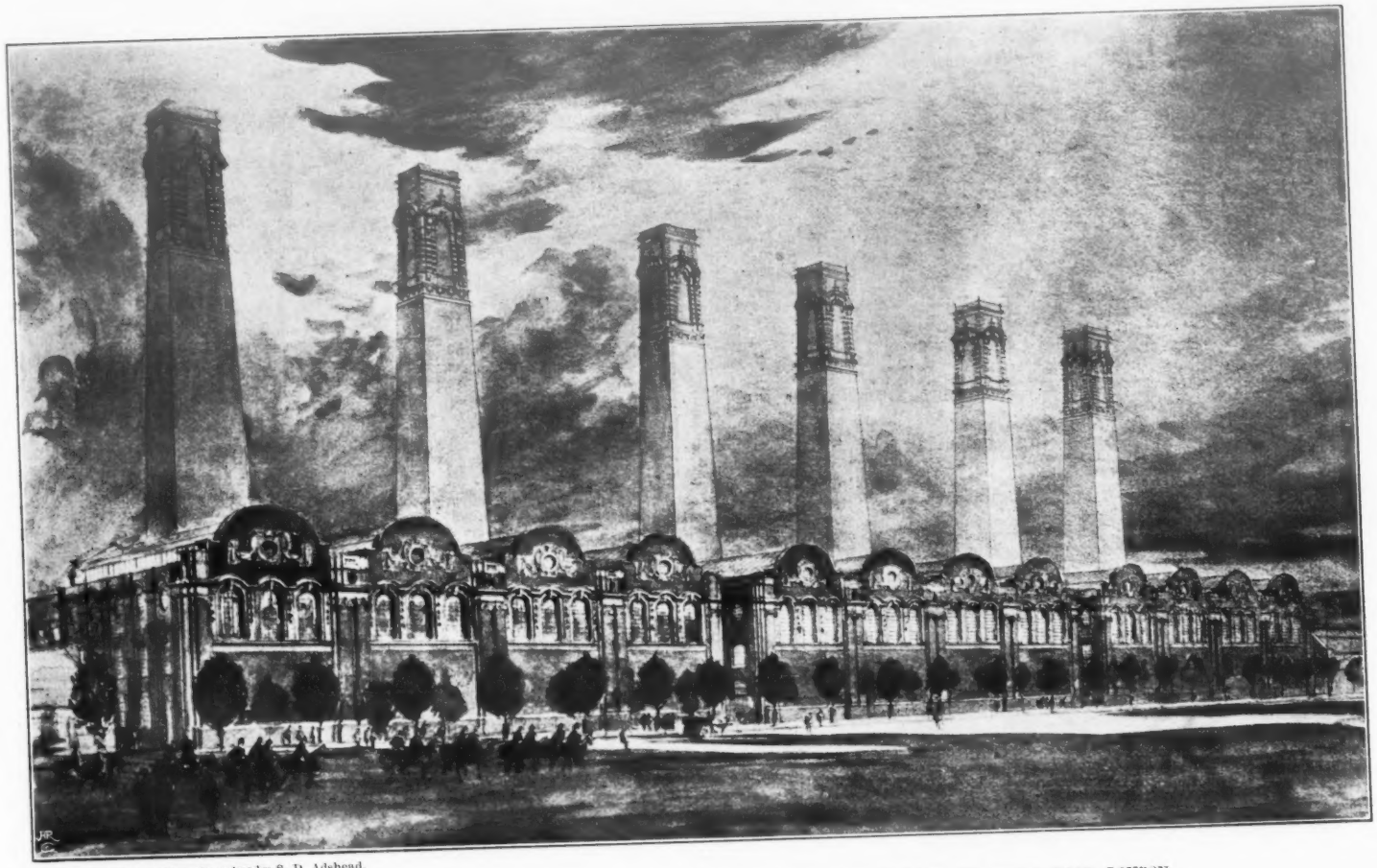
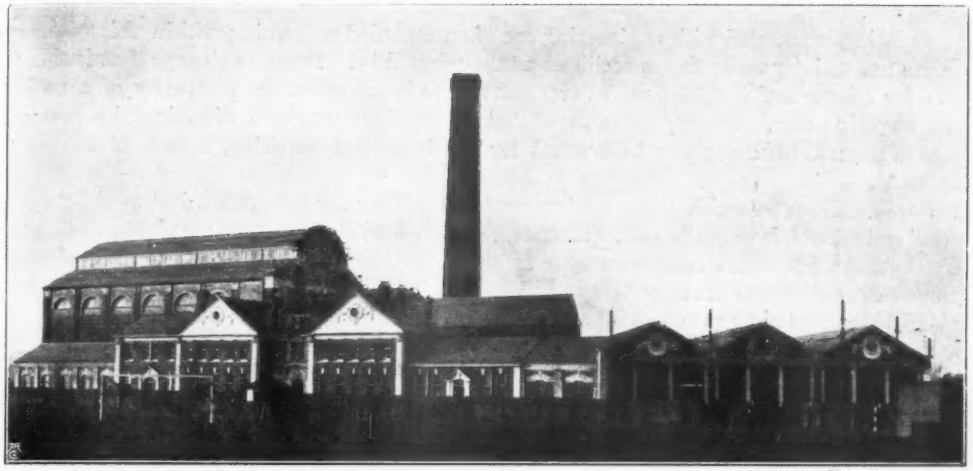


From a Water-colour Drawing by S. D. Adshead.

THE POWER STATION OF THE CENTRAL ELECTRIC SUPPLY COMPANY, LTD., GROVE ROAD, ST. JOHN'S WOOD, LONDON.



ELECTRICITY WORKS OF THE CORPORATION OF IPSWICH : NORTH-EAST VIEW.

NOTES ON THE DESIGN AND CONSTRUCTION OF BUILDINGS CONNECTED WITH THE GENERATION AND SUPPLY OF ELECTRICITY KNOWN AS CENTRAL STATIONS.

By Charles Stanley Peach [*F.*].

Read before the Royal Institute of British Architects, Monday, 28th March 1904.

IT has been the province of the architect in all ages to play an important part in the successive stages of the economic development of mankind, to keep in touch with his times, and to express in the buildings the sentiments dominating the period in which he practised his art. Thus the buildings of every period indicate the habits and mode of life of successive generations, and show posterity what men did and thought in bygone days.

The most noticeable feature of our times is the rapidity with which scientific discoveries are applied to commercial purposes, in consequence of which new industries constantly arise. The buildings required for these industries form an important branch of modern practice. Therefore, not only are they of considerable interest to the architect as being work with which he is immediately concerned, but it is essential that they should be closely studied if the architect is to maintain the traditions of the past and to take a like prominent part in the progress of the present day. That which is passing before our eyes does not attract like that which is woven into the warp of history; so it is not to be expected that the same interest can be aroused for buildings serving a modern purpose as for those connected with vocations or occupations which have been followed by mankind for centuries. Undoubtedly, buildings to which the romance of the government or of the religion of a nation is attached, the dwellings in which individuals of the race have been born, and lived, and died, must ever exercise a greater fascination over mankind than those in which their lives are spent toiling for their daily bread. Indeed, the latter buildings often seem to be regarded as of small account, as though they were something altogether apart from the life of the people, instead of being as they are, to a vast majority, the alpha and omega of existence.

Buildings connected with engineering are often regarded as coming within this category and are not as interesting to the architect as they should be. It seems strange that it should be so, for science and its allied useful arts exert more influence on the prosperity of a nation than anything else. Among these arts, that of manipulating and diverting the greatest forces of nature, turning them to account for the benefit of mankind, is one of the most important.

The buildings in which these achievements of science are performed, just as the "day's work," will doubtless obtain from posterity some measure of esteem, as places associated with the marvellous work carried on by men of the present day, and this, as their characteristic features become familiar, may even arouse interest in their construction, form, and embellishment. At any rate, as buildings characteristic of the period in which they are erected they may claim, even to-day, some position in architecture, a position which will probably rank higher in the future, as the relation of electricity to modern life and the profound influence which it is exercising on civilisation becomes better known. The associations connected with a building, acting on the imagination, often cause its architecture to command an admiration out of all proportion to the intrinsic merits of the edifice, because it is difficult to disassociate the form and design of the walls themselves from the sentimental interest evoked by the events which have taken place within them. If the importance of the purpose for which the building is required is not fully appreciated, it is often difficult to remove the obstacles which stand in the way of suitable architectural treatment.

The buildings connected with the generation and supply of electricity—commonly known as central stations—are a conspicuous example of the structures required by modern scientific industries. In less than twenty years they have developed from small commonplace sheds to complex structures frequently of great size, occupying prominent sites, and supplying power for innumerable purposes. Upwards of 750 of these buildings have in about fifteen years been erected in the United Kingdom alone, and a much greater number abroad. Although unusual in many respects, even from the very commencement, the early stations did not exhibit in a marked degree those special features now associated with them. This is not surprising, because when the industry started the demand for energy—in other words, the business of the undertaking—was in existence before sufficient progress had been made in electrical knowledge to enable the want to be supplied.

The advantages of electricity, however, were appreciated sooner abroad than in Great Britain, and so the industry had made considerable progress in foreign countries before a fair start was made here. The lead thus gained has never been lost, and therefore it is useful to study foreign practice, for that which obtains abroad to-day is more or less that which will be put into practice in England to-morrow, and foreign stations become a useful guide to what should be provided for future extensions.

In this country also it was hampered for a time by unfortunate legislation, but the moment this was altered the industry burst into existence suddenly; it developed with extraordinary rapidity, the capital invested in it increasing from a few thousand pounds in 1888 to upwards of £64,000,000 in 1903. Designs were therefore prepared with the utmost speed, the work was rushed through as fast as it could be done, invention proceeding simultaneously with construction. Frequently machinery was installed and current generated and supplied long before the works were finished, and while building operations were still in progress, and while electrical knowledge was still in rather a rudimentary state. Under such conditions it is obvious that some points could not fail to be overlooked, for designs could not receive the full and deliberate thought which is necessary for the successful solution of new and difficult problems.

The various systems of supply have also been in a continuous state of evolution, and requirements have constantly changed. So the buildings first erected were quickly superseded by other types, and information obtained from existing buildings is not so generally useful as it is in cases where slower progress on more settled lines has taken place.

Now matters are assuming more or less definite shape. The present, therefore, seems an opportune moment to consider the buildings recently erected and those which are likely to be required in the immediate future.

Primarily Central Stations may be divided into three classes :—

1. Power Stations.
2. Sub-stations.
3. Direct Supply Stations.

The latter being subdivided into two types :—

(*a*) Simple ; and (*b*) Composite.

The distinction between these classes is fairly well marked, but to some extent they merge gradually into one another and classes and types overlap. In each class there are several different kinds dependent on the source from which power is derived. First, if from the natural elements—air, water, electricity ; secondly, from the conversion of natural products—coal, oil, or gas.

Further subdivisions of each class and type arise under headings too numerous to mention, among which the kind of plant installed, the actual and relative position of plant in the buildings, and method of working and combination of plant, are among the most important. Although at first sight these different types and classes appear very similar they are really very different, but the common purpose which they all serve naturally gives rise to many special features present in all.

The power station is the class now coming into vogue, and is the real central station. It is the centre at which power is generated for the district allotted to it, whence it is supplied in bulk to sub-stations for distribution. Larger and more powerful machines are usually installed in power stations than in other classes.

The sub-station is the satellite of the power station. Its province is to receive the power from the central source, and retail or distribute it to consumers in its immediate vicinity.

There are two principal subdivisions :—

(1) Sub-stations housing machinery, and batteries or accumulators for storing electricity.

(2) Sub-stations without storage and accommodating machinery only.

The direct supply station is a centre at which the power is both generated and distributed. The simple direct supply station comprises the machinery departments only. The composite direct supply station is rather an electricity works, and contains, in addition to the rooms for machinery, accommodation for many other departments of the undertaking, such as meters, mains and roadwork, tramways and administration departments, sometimes also destructor, &c., but the accommodation of these stations varies considerably in every case.

Obviously the initial source of power is that which exercises the greatest influence on the design and construction of a central station. As might be expected, the more directly the natural element is employed, the fewer processes are involved and the more simple is the building required.

POWER STATIONS.

The simplest kind of power station is that in which air or wind is used as the source of power. There is at present only one station of this kind. It was erected in 1902 at Askov, and consists of a single room containing dynamos and accessory machinery. The windmills are above the building and are connected to a counter shaft, whence the dynamos are driven by belts. It is reputed to have run continually since that date, with small but satisfactory results.

A great number of stations using water as the source of power have been erected abroad, but there are none at present of first-class importance in Great Britain. The water-power station is usually a one-story building above the ground line, having one, and occasionally two or more principal rooms. In the engine room is placed electrical plant, dynamos and switchboard, the turbines or water-wheels being in chambers, tunnels, or races below the floor level. The turbines and dynamos are nearly always directly coupled together by a shaft, and not driven by belts or ropes. If the current is generated at comparatively low tension and transformed up for transmission, the electrical plant is usually arranged in two rooms, the step up high tension transformers being separated from the generating plant. A few small offices are required for the engineer-in-charge, and rooms for the staff.

If the mains are taken overhead the switchboard is often placed in an annex to the engine room, and forms the end, or part of a side. This is a good arrangement, as a separate chamber for the mains is thus formed, which, being carried up as a tower, enables the mains to leave the station from the top at a sufficient height above the ground. If the mains are laid underground the same arrangement of switchboard is sometimes adopted; the space at the back forms a convenient mains room whence they descend to the culverts under the roadway.

The flumes, aqueducts, weirs, and sluices required for diverting and controlling the water and directing it to the turbines, and for leading it back to its natural channels; the foundations of these buildings, honeycombed with chambers and tunnels, are the most interesting parts of the works. Their construction requires considerable technical skill, as almost every kind of vault, dome, and curved structure meeting and intersecting at every kind of angle is to be found in these buildings.

Probably Niagara is the best known water-power station. The reservoirs are the great lakes of North America, which are said to contain upwards of 6,000 cubic miles of water, covering an area of 90,000 square miles. The natural aqueduct is the Niagara River, the channel of which is about a mile wide, but bifurcates into two narrower channels just below the power station. The river descends 55 feet in the rapids above the falls, and has a depth of over 20 feet over the crest, where it descends in the principal fall 165 feet more. The volume of water has been calculated by Professor Unwin to be upwards of 275,000 cubic feet per second, and it is estimated that these falls represent 7,000,000 h.p., the greater part of which can and eventually will be made available. In other words, a force equivalent to the consumption of over 200,000 tons of coal per day (being practically the daily output of the coal mines of the world), or the combined effort of 49,000,000 men, or which would raise over 100,000,000 tons one foot high in one minute, will be penned in and controlled in the buildings. The machines dealing with this power must all be fixed rigidly in one place, and will be concentrated in a comparatively small area.

An example like this brings forward very forcibly a point in the design and construction of these buildings which deserves careful consideration.

This concentration and fixing of machinery of enormous power within a building is a

new feature. It may be that there will be but few other stations quite as powerful as Niagara, but even those of 150,000 or 200,000 h.p., with probability of considerable future enlargement, of which many are now in course of erection, insignificant as they seem by comparison, will nevertheless enclose and uphold forces infinitely greater than anything which has hitherto been contained in a building. It is obvious that it is both advisable and economical to calculate the structure with an ample margin of safety, and to allow considerable strength above what would be considered sufficient in ordinary practice. This is necessary, not only that the buildings may be strong enough in the first instance, but also that they may be durable and capable of that considerable enlargement which will be required as years go on.

The power station of Niagara was designed by Messrs. McKim, Mead and White, of New York, Mr. W. A. Brackenridge being the engineer. It is faced with limestone, hammer-dressed, and is a plain but effective building. The engine-room No. 2 is 462 feet long by 62 feet wide, and 60 feet high. The first half of engine-room No. 1 is 450 feet long by 62 feet wide, 39 ft. 6 in. to springing of roof, and 60 feet to ridge. There are 21 generators installed of 5,000 h.p. each. The turbines are 140 feet below the dynamos, to which they are connected by perpendicular shafts about 140 feet long. Each generator weighs 170,000 lbs., of which 79,000 lbs. is the weight of the revolving element, working normally at 250, but capable of a maximum of 400 revolutions per minute. When the whole work is complete, over 48,370 tons will be revolving in the buildings at this speed day and night. The present output is 105,000 e.h.p.

There are other large water-power stations in America, notably at Sault Sainte-Marie, Michigan, where the power is obtained from the rapids of the Sainte-Marie River between Lake Superior and Lake Huron, where it is estimated that about 260,000 h.p. is available. This station is nearly as powerful as Niagara, as the plant already installed is capable of developing 60,000 h.p. In both these stations the turbines are directly coupled to the engines.

The city of St. Paul, Minnesota, also derives energy from a water-power station, situated on the Apple River, Wisconsin. In this case the current is generated at 800 volts, is transformed up to 25,000 volts, at which tension it is transmitted, and is transformed down in the sub-stations in the city before being distributed.

The power house is a plain brick structure 144 feet long by 57 feet wide, on masonry foundations, and consists of two rooms. The plan is somewhat unusual, because in the larger are placed the dynamos, switchboards, and transformers, and in the second room, the water-wheels and accessories. The water is brought to the wheels by a steel penstock on the outside of the wall, with branches to the interior. The mains leave the building from a tower over the switchboard, and the current is conveyed by overhead conductors to sub-stations in the city.

Some of the European water-power stations are interesting examples of well-studied architectural treatment. Full advantage has been taken of the shape of the building required for the arrangement of plant. The most important members of the construction have been accentuated in the elevations, and the buildings have been carefully grouped to accord with the locality in which it has been necessary to erect them. Perhaps the most picturesque is the power station at Tivoli, on the Tiber, erected in 1891 [fig. 1]. The energy for the city of Rome is generated at this station, whence it is transmitted seventeen miles at a tension of 5,500 volts to the sub-station at Porta Pia, in Rome. The works are almost monumental in character.

The great aqueduct which brings the water to the power house is a striking instance of the application of old-time methods of building to modern requirements. It bears a strong resemblance to the Aqua Virgo of Agrippa, and the general construction is practically the same as

other aquæ built in the time of the Roman Empire. The purpose, too, is not dissimilar, since it is to minister to the wants of the "Eternal City."

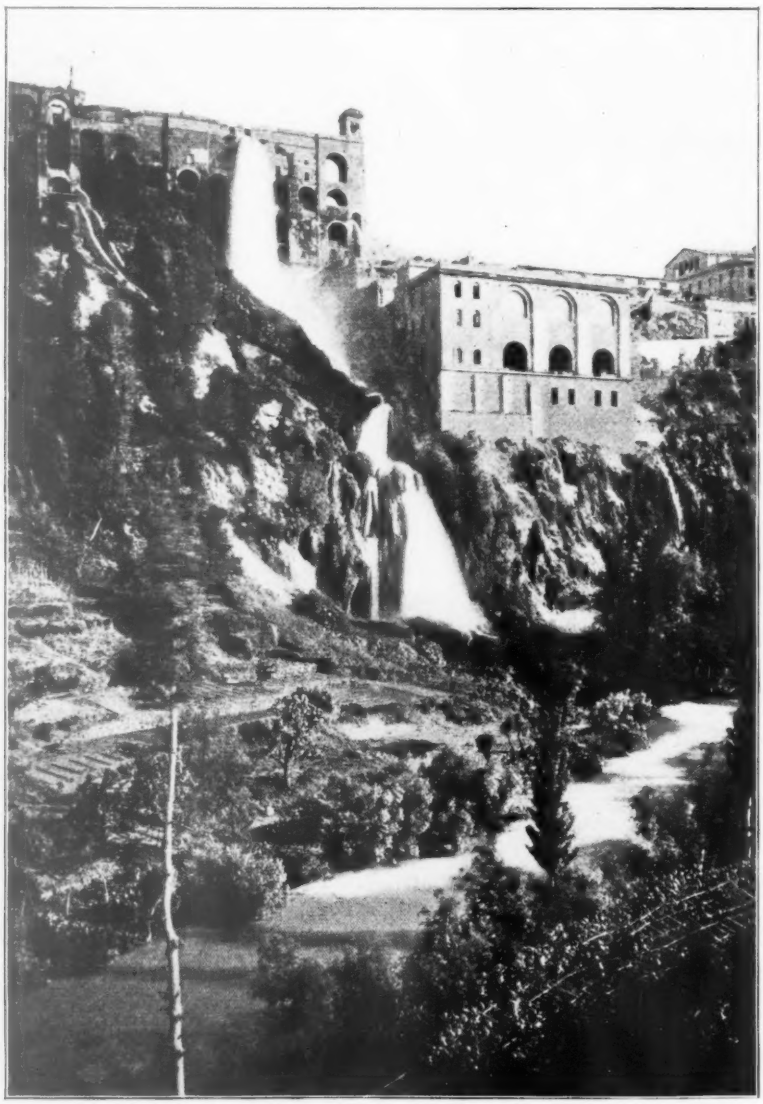


FIG. 1.—THE ELECTRIC POWER STATION AT TIVOLI, ON THE TIBER.

(Reproduced by permission of the proprietors of CASSIER'S MAGAZINE.)

As it follows its winding course through the hills, its arches rest in many places on the site of an ancient aqua, with which it is almost incorporated, as was the Roman custom.

The aqueduct has a capacity of 425 cubic feet per second, and the smaller conduit which carries the water to the turbines has a capacity of 140 feet per second.

The power house is as simple as a building well can be. It seems to cling to the hill, and to be almost part of it. The plain wall surface and the few arched openings, eminently

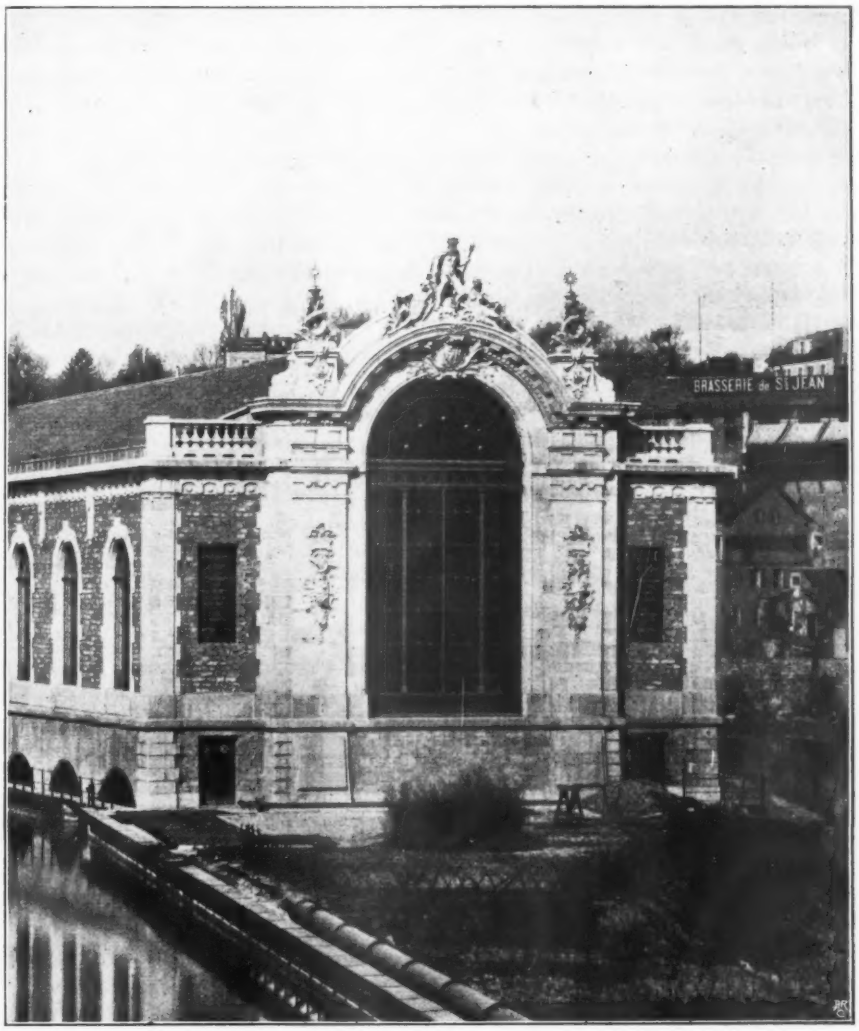


FIG. 2.—THE 6,000 H.P. WATER-POWER STATION OF THE MUNICIPALITY OF GENEVA. FROM THE PONT DE LA COULOUVRENIÈRE.

suited to the climate, harmonise perfectly with the dark green of the cypress, the varied colours of the vine, and the grey foliage of the olive trees which clothe the country round. The beauty of the neighbourhood has not been spoilt, although it has been necessary to erect a building to serve a utilitarian purpose and for the benefit of another city many miles away.

Of almost equal architectural interest, though of a different kind, is the first power station

at Geneva, situated at the outfall of the Rhône from Lake Léman [fig. 2, and pl.]. It is in the heart of the city, and occupies a very prominent site. It was erected in 1886 under the direction of Colonel Turrettini, Director of Public Works for the Municipal Council.

The engine-room is a separate building from those containing dynamos. It contains the pumping machinery—water being the transmitted power instead of electricity. It is a building of considerable architectural merit. In it eighteen turbines of 300 h.p. each are installed, which pump the water under pressure to sub-stations, where it actuates turbines direct coupled to horizontal dynamos, which in turn generate the electric energy used in various sub-districts of the city. The station, which supplies energy mainly for lighting purposes, stands on an island in the lake, opposite to the Isle de Rousseau, has also been carefully designed, and is not unsightly although a very plain and simple building.

The second water-power station of Geneva is at Chèvres, four miles out of the town, below the junction of the Arve and the Rhône [pl. xv., xvi.]. It is of the ordinary type, containing turbines direct coupled to dynamos. It was erected in 1892. It is a long, low stone building 492 feet by 103 feet wide. The engine-room is 448 feet by 98 ft. 6 in., and 30 feet high from ceiling to floor, and accommodates fifteen turbines of 1,200 h.p. each coupled direct to dynamos, the total output being 18,000 h.p. The dynamos weigh about 154,000 lbs.; the moving part of the machine weighs 35,200 lbs., and revolves at a speed of 80 revolutions per minute. The energy is generated at a tension of 2,400 volts. The works were completed in 1896, and were carried out under Colonel Turrettini and M. Butticaz.

An important German water-power station is the Rheinfelden, fifteen miles above Basle, on the Rhine [fig. 3]. There, about 12,000 h.p. is installed. It was designed and erected by

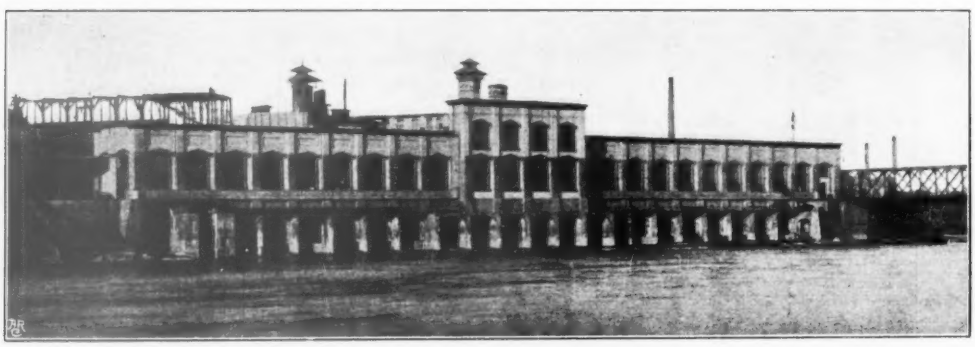


FIG. 3.—THE 12,000 H.P. WATER-POWER STATION OF RHEINFELDEN.

the Allgemeine Elektricitäts-Gesellschaft of Berlin. There are also important installations at Jajce, on the river Pliva, in the province of Travnich, Bosnia, where about 9,000 h.p. plant is installed; at Corbières, in France, at the entrance to Gorges of Saint Georges near Axat, Department of Aude. In this station power is derived from a fall 100 metres high. There are eight units of 800 h.p. water turbines direct coupled to dynamos: 6,400 h.p. at present installed.

Although there is not likely to be any great demand for water-power stations in England, they are worth careful study, for many things can be learnt from them which can well be applied to the improvement of steam stations.

By far the greatest number of stations derive their power from the conversion of natural

products, the chief of which is coal. The steam-power station, which is a class of comparatively recent introduction, is a more complicated building than the water-power station. Owing to the larger size of the rooms, the greater number of departments, and the more complicated construction required, these buildings present even greater opportunities to the architect. No doubt there will be a great demand for them in the future, for they are the direct outcome of the system of generation and supply which now seems in a fair way to receive general acceptance. These stations generally consist of—

Engine house, in which are placed the engines and dynamos, the apparatus for the control of the current and mains leaving the station. If condensing plant is used the necessary apparatus is placed either on a gallery, at the floor level, or below the floor of the engine room.

Storage of electricity. A battery room for accumulators.

Boiler house, in which are installed boilers or steam generators, of which there are many kinds; the main flues, and apparatus for feeding coal to the boilers, and for removing ashes. The economisers for heating the feed-water are also placed in this building.

Pump room. Sometimes an annex, but often an enclosed place in the boiler house.

Chimney shafts.

Coal store, which should provide ample space for fuel and for handling coal, and for the conveying apparatus for bringing coal into the store. In connection with this department there are often railway sidings or similar works.

In connection with the first three departments, workshop and general stores, offices for engine-room staff, mess rooms, lavatories, w.c.'s, &c., for men.

Water department, in which are feed-water tanks, frequently also water-softening plant, cooling towers, and sometimes cooling ponds or lodges. Frequently a separate pump-house or building for condensing plant.

Probably the first station of this kind was that of the London Electric Supply Corporation at Deptford, designed by Mr. Ferranti in 1888 [fig. 4]. A part only of the station as first planned has been built. The original design, as will be seen from Mr. Ferranti's pencil sketches, contemplated a two-bay engine room one story high, with a four-story boiler house parallel to it and divided by one main wall—very similar to the prevailing type of American town stations of the present day.

The boiler house was 200 feet long and 90 feet wide, and contained 24 boilers on the ground floor. The floor over was designed for 24 boilers, and above this a coal store with sloping floor (the first of this kind), having a capacity of 4,000 tons, whence the coal descended by gravity to the stoking floors. The chimney shafts, of which there were two, were peculiar, as each contained four flues, two to serve the upper and two the lower boilers. Each engine-room bay was to be 200 feet long and 66 feet wide, provided, one with a travelling crane of a capacity of 25 and the other 50 tons. The first bay next the boiler house was designed to contain two 1,800 h.p. engines, driving dynamos by ropes, the current being generated at 10,000 volts.

The second bay was designed to receive four 10,000 h.p. engines and dynamos.

Although the original design has not been carried out in its integrity, and the character of the building has been considerably changed by additions subsequently made to it, it was at its inception simply a power station, and conceived with a wonderful prescience of the line upon which the system of generation and supply of electricity was likely to develop in the future. It was perhaps somewhat premature, but it undoubtedly pointed the way to what is now being done both in this country and abroad. Some of the great power stations erected in America ten years later followed very closely on the lines of Mr. Ferranti's design.

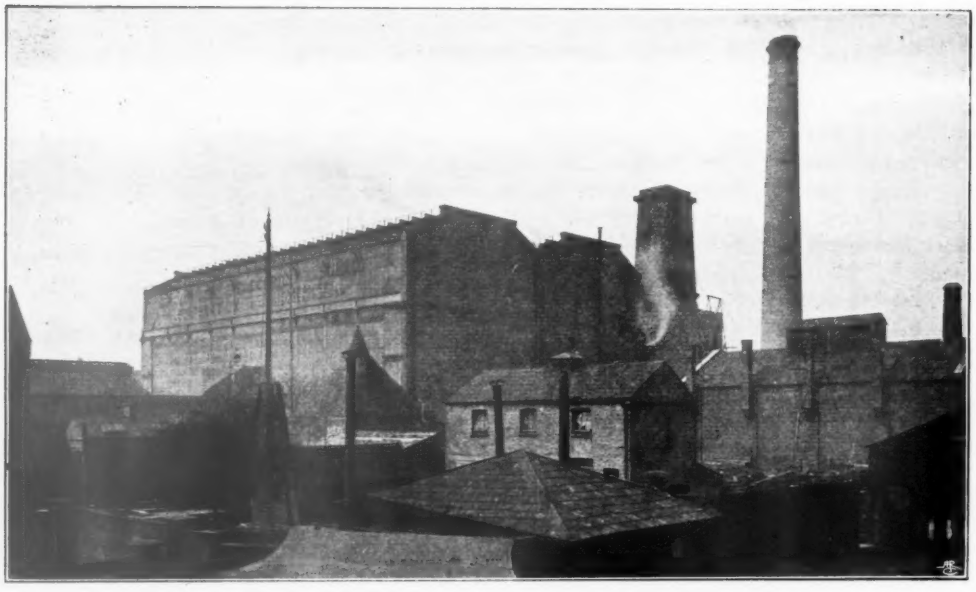


FIG. 4.—DEPTFORD POWER STATION OF THE LONDON ELECTRIC SUPPLY CORPORATION, LTD.

There are great differences in the arrangement of these buildings, even when the same kind of machinery is installed. To some extent these arise from local customs or climate, but more frequently from individual ideas. In foreign countries many stations have been designed by architects and engineers in the employ of very large companies which take a contract for the complete electrical supply of a town or district and manufacture and supply the plant. Hence there is a great similarity in places served by the same company, but considerable difference between adjoining districts and between one country and another.

In America, owing in a great measure to the system of laying out the towns in blocks of uniform size and shape, it is difficult to obtain large areas of land in cities. The price also is high, hence American town practice inclines to a rectangular building of the superficial area of a city block. The building is divided nearly centrally by a main division wall, on one side of which is placed the engine house, on the other the boiler house. The engine house is generally a one-story building, above ground, with a basement below. Vertical marine-type engines direct coupled to dynamos are usually adopted, which are erected on the ground floor. The steam turbine is now coming into use, which will probably take the place of the vertical engines in the future, where facilities for condensing exist. The switchboards are placed on galleries; the leads from the machines and mains leaving the station are arranged under these galleries. The condensing plant is generally in the basement. The boiler house usually contains horizontal water-tube boilers, arranged in one or two rows on two floors, with economisers and ash conveyers on separate floors. The coal store is over the upper boiler house. The boiler house is practically a five or six story building at least, for the conveyers occupy a floor to themselves over the coal store.

The power house of the Manhattan Railway Company, New York, erected 1900–1, is a very complete example of this practice [pl. xiv.]. It was designed by Mr. C. H. Pegram,

assisted by Messrs. W. C. Phelps and C. Wellesley Smith. It is located on the East River between Seventy-Fourth and Seventy-Fifth Streets.

It has a frontage of 115 feet to Exterior Street, which borders the river, the whole site being 204 ft. 4 in. wide, and 588 feet long on one side and 531 feet on the other. The station is designed for a maximum capacity of 100,000 h.p., and the ground is considered to be sufficient for future enlargement of 50,000 h.p. more. It supplies seven sub-stations. The building is a massive square structure, of skeleton steel construction, with fairly heavy enclosing walls. The base is of rose-coloured granite, the walling above flashed bricks of a prevailing brown tone, and a red-tiled roof. The windows have semicircular heads. They are all in the upper part of the building, and are 14 feet wide, 45 feet high, and spaced about 35 feet centres. The building is 66 feet from top of granite base to top of parapet. The windows being unusually large detract somewhat from the scale of the building, which is not so impressive as might be expected from its great size. The engine-room is 93 ft. 6 in. wide and 128 ft. 6 in. long, and 107 feet high from engine-room floor to skylight.

The engine foundations are more or less separate blocks, each 40 feet by 40 feet by 21 feet thick, and these blocks alone contain about 9,000 cubic yards of concrete.

There are eight engines, vertical marine type, direct coupled dynamos of a nominal rating of 5,000 k.w. with total overload capacity of 7,000 k.w., or 10,000 e.h.p. They are 42 feet high, and weigh about 889,000 lbs. The revolving part is 32 feet in diameter and weighs 370,000 lbs.

The boiler house is rather longer, being 104 ft. 2 in. wide and 128 feet high. The coal store has a capacity of 15,000 tons. There are four plain brick circular shafts with octagonal bases for a height of 73 feet; each is 17 feet inside diameter, and 278 feet high. The foundations are 33 feet by 33 feet, and rest on the solid rock. The boiler house stanchions carry a load of about 500 tons. Under them is a sub-base of cast iron bedded on the concrete. The stanchions are spaced about 20 feet centres in one direction, and 15 feet in the other. The steel is stressed in the lower part up to 13,500 lbs. per square inch of sectional area. The building contains about 6,000 tons of steel and iron construction.

These particulars give some idea of the size and weight of these structures, and the enormous forces at work in them. The special construction problem which this type of station presents, apart from the mere support of the great loads of and in the building, is the manner in which these heavy loads are disposed on the site. Nearly three-quarters of the whole load is concentrated on half the area, and the moving machinery and about a quarter of the total load on the other half. By this arrangement the effect of the vibration is vastly increased, and it is difficult to prevent it from being transmitted to a considerable distance beyond the building. On hard and solid rock this is not so noticeable, but on compressible or water-logged soils it is a serious matter. In some cases piles have been driven over the whole site, with the twofold purpose of increasing the supporting power of the subsoil and preventing it working out from under the foundations, and reducing the tendency to increase and transmit vibration. But this is an expensive way of dealing with it, and of doubtful durability.

The special conditions present render this design of station unsuitable for sites of which the subsoil is liable to consolidation when shaken, as is the case in many parts of Great Britain, especially round London, unless precautions are taken to prevent the consolidation being much greater under one part of the building than under another. To some extent this can be overcome by constructing vertical retaining walls below the level of the general foundations, but even this is not always successful with this combination of load and movement. It is expensive, and, taken in conjunction with the greater cost arising from placing plant on upper floors, it is probable that the purchase of sufficient additional land to accom-

modate all the plant on one floor will be found much cheaper, especially as the shape and area of land in or near towns in this country are not restricted to the same extent as in America, and land can be acquired by compulsory purchase for central stations.

The Manhattan station is typical of central stations generally in one respect. It is built on a bad foundation, the gneiss bed rock bottom being deeply eroded by streams which formerly traversed it. It was therefore of unequal supporting power, which accounts for the apparently unequal strength and thickness of foundations. The plans would be misleading without this explanation. Large quantities of water are used in connection with the work carried on in central stations, therefore they are frequently erected on the banks of rivers and canals, where the subsoil is hardly suitable for such buildings and careful adjustment of the weight is necessary. Sometimes the subsoil is hard in places and yielding in others. In such cases foundations like those of Manhattan have been found suitable, but in very soft soils much waterlogged it is as a rule better to support the load on concrete floats proportionate to the weight, allowing somewhat more than half the load which would be taken for an ordinary building. A thick float of concrete all over the site is a common method of meeting the difficulty, both in English and German practice. It is a good plan on clay, but should be keyed on the underside on looser soils.

In Calcutta, where the soil is soft and compressible, the float system was successfully used by Colonel Crompton, who allowed a load of 1 ton per square foot without appreciable settlement.

At Amsterdam this method was adopted, the ground being first consolidated with piles, which were scientifically spaced in proportion to the load brought down at different points [pl. xi. and xi. A]. The heads of piles should be kept clear of the concrete, otherwise they are liable to rot.

The Waterside power station of the New York Edison Company, built in 1901 and located in First Avenue on the block between Thirty-Eighth and Thirty-Ninth Streets, and running to the East River, is a very similar building. The site is 272 ft. 6 in. by 197 ft. 6 in. This building stands on the hard and firm rock which underlies the greater part of the City of New York. It is very similar to Manhattan, with the large semicircular heads to the windows characteristic of American practice in these buildings. It is faced with red sandstone and yellow brick. It is also a skeleton steel structure.

The boiler house building is 76 feet by 267 ft. 10 in. by 148 feet high, and contains 56 horizontal water-tube boilers rated at 650 h.p. each, but said to actually develop 1,625 h.p. each. They are arranged in two rows on two floors. The engine-room is 115 feet by 267 ft. 10 in. by 136 feet high, and contains sixteen engines of the Westinghouse Machine Company type, direct coupled to sixteen General Electric 4,500 k.w. three-phase generators delivering twenty-five cycles alternating current at a tension of 6,600 volts. The revolving part weighs 130,000 lbs., the armature 125,000 lbs., and the bed-plate 20,000 lbs., the whole generator apart from the engine weighing 275,000 lbs. There are four circular steel stacks, each 17 feet internal diameter, 132 feet above roof, and 200 feet from grate surface of the lower boilers.

Steel stacks are now coming into use in Great Britain, and some particulars about those at Waterside may be useful. They stand on brick pedestals about 80 feet high, the shaft above being constructed with steel plates—

$\frac{5}{8}$ in. thick for 44 feet
$\frac{1}{2}$ „ „ 44 „
$\frac{3}{8}$ „ „ 44 „

The joints are rivetted. They are lined with firebrick 8 inches thick for one-third of the height, above that with red brick (ordinary good tough building bricks). The linings are

carried on rings of angle iron in independent sections 20 feet high. There is an air space of 4 inches between the lining and stack.

The system of constructing linings for shafts in sections in this way now meets with much favour in America both for steel and brick shafts, and has been used on some brick shafts in England and on the Continent. In brick shafts the sections are carried on projecting header courses at suitable intervals. Very careful and accurate adjustment of the spaces between the supporting courses is necessary, as different kinds of firebricks vary considerably in expansion. The average expansion of the core is about 6 inches in 100 feet. Unless great care is taken the expansion of the sections will inevitably break the joint at each oversailed course. As soon as the shaft is worked, the headers will be snapped off, and then the lining becomes just the same as an ordinary core built up from the bottom, but of course not so strong. This method of construction is said to facilitate repairs, but when once the supporting courses are broken, this convenience no longer exists. The consolidation in building cores must also be allowed for, as this, even with firebricks set as close as possible, often amounts to as much as 4½ inches in 100 feet. In several shafts otherwise excellently built serious injury has arisen within a few weeks of being used from this point having been overlooked. What the final result will be cannot be stated at present, as the stacks have not been long enough in use to enable one to express a very definite opinion about them, but in some not five years old the horizontal joints are already broken through at intervals of about 20 feet for the lower 100 feet of the stack. In the case of a shaft recently shut down for repairs it was found that the difference in length of the lining when the shaft was in use was 9 inches in 97 feet.

The Kingsbridge power station of the Third Avenue Railroad Company of New York is one of the latest stations of this kind erected in America [pl. vi., vii.]. It was erected in 1900–1, and has a rated capacity of 72,000 h.p., and a maximum of over 100,000 h.p. The whole installation was designed by Westinghouse, Church, Kerr & Co. It occupies a site 350 feet long and 250 feet wide. It is very similar to Manhattan and Waterside, but is built on piles, and steam turbines are installed instead of vertical marine-type engines. The subsoil is a fine sharp sand, into which 15,000 to 16,000 oak piles 40 feet long were driven, spaced at 28 inches centre to centre. They were driven at the rate of about ten minutes each pile. Over the heads a slab of concrete, average 8 feet thick, was laid covering the whole site. The concrete was composed of one part of Portland cement to two of sand and four of stone. The maximum bearing weight on the foundation is 15 tons per square foot. The building is skeleton steel construction. The lower part of the walls is granite; the upper part is built with curtain walls carried on the steel frame, and is faced with red brick and stone dressings. There are four chimney shafts, each 12 feet internal diameter, 200 feet high.

The Americans have displayed great ingenuity in installing very powerful plant on sites of small superficial area; stations with plant on more than one floor are more common there than elsewhere. A remarkable instance is the Edison station at Philadelphia [fig. 5, p. 292], where the plant is installed in an eleven-story building, each department being placed on a different floor, one above the other. It is not, however, an arrangement which would be adopted in ordinary practice, if by any possibility it could be avoided.

A somewhat similar practice obtained at one time in Germany, but it was never carried to the same extent as in America. The station in the Luisenstrasse, Berlin, of the Berliner Elektricitäts Werke, designed and erected by the Allgemeine Elektricitäts-Gesellschaft about 1889, is an instance. In this station three 3,000 h.p. vertical marine-type engines directly coupled to two 250–280 volt continuous current dynamos are placed on the ground floor, eight horizontal water-tube boilers on the first floor immediately over them. The coal store

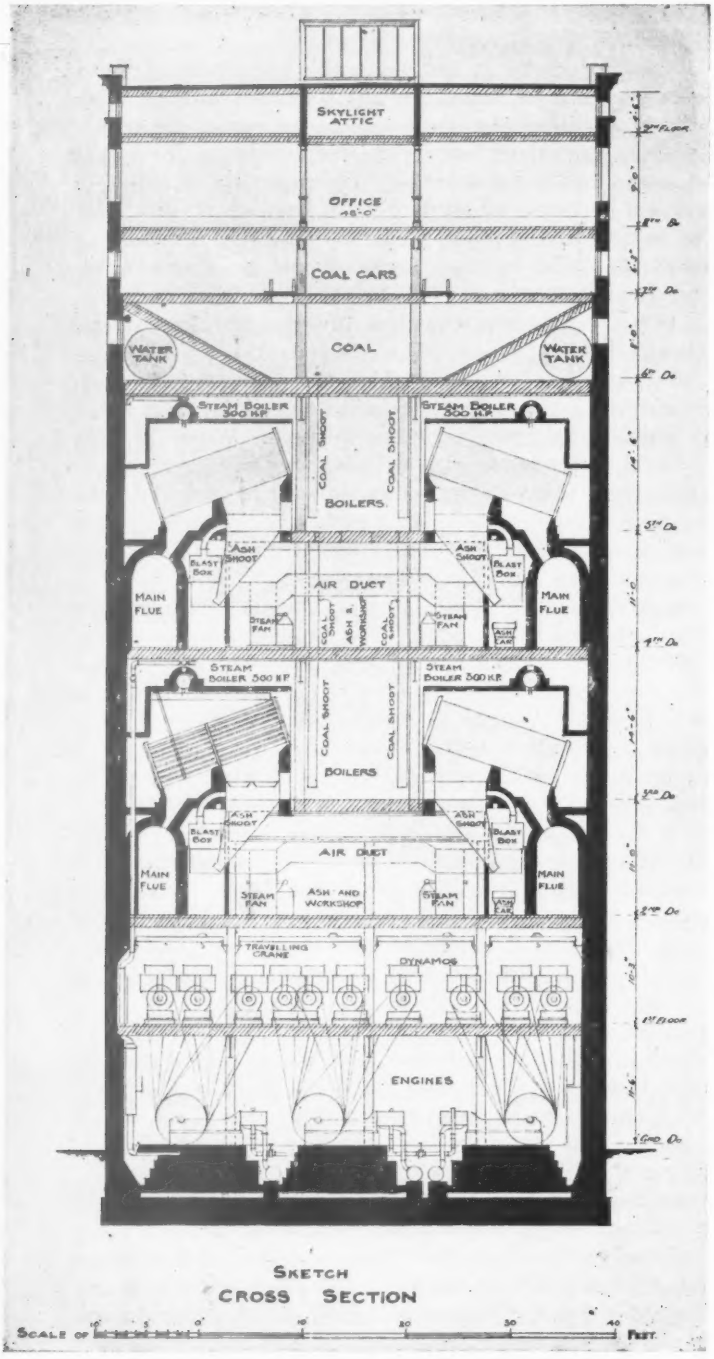


FIG. 5.—EDISON ELECTRIC-POWER STATION, PHILADELPHIA, U.S.A.

is on the top floor over the boilers. Although by no means a good arrangement, it is on the whole better than placing boilers in a basement below the level of the engines, which was a contemporary style now obsolete. The base of the chimney contains offices, but this also has not been successful, and should not be followed.

There are very few examples in Great Britain. The station at Bristol, designed by Mr. Parshall for the United Electric Tramways Company in 1899, is perhaps the most important. Its elevations, designed by Mr. Curtis Green, are alone sufficient to deserve careful study, apart from the skilful treatment of the engineering work [figs. 6 and 7, p. 293].

The present European practice inclines to the use of the horizontal engines directly coupled to dynamos with horizontal water-tube boilers, all plant placed at or about the ground floor level, and only the coal store being on an upper floor. Condensing plant and steam pipes are in the engine room basement. The latest stations in Vienna and Buda-Pesth of the Siemens Company, and Ober-Spree and Moabit, erected 1902–3, the great power stations of Berlin [pl. x.] and at Amsterdam, and the Hamburg power station supplying power for the docks, all stations designed by the Allgemeine Elektricitäts-Gesellschaft, are on these lines.

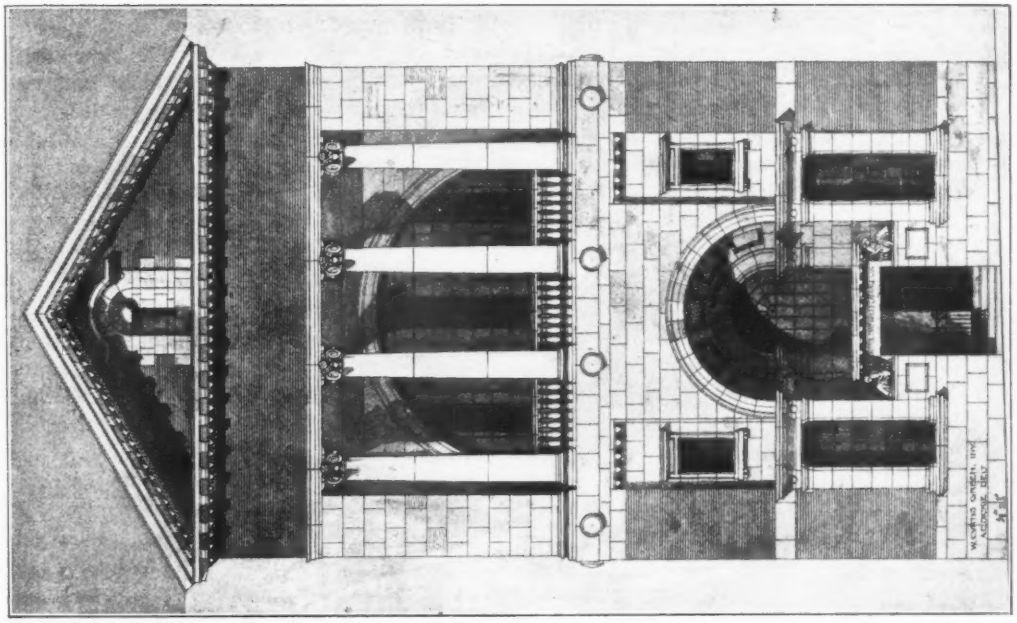
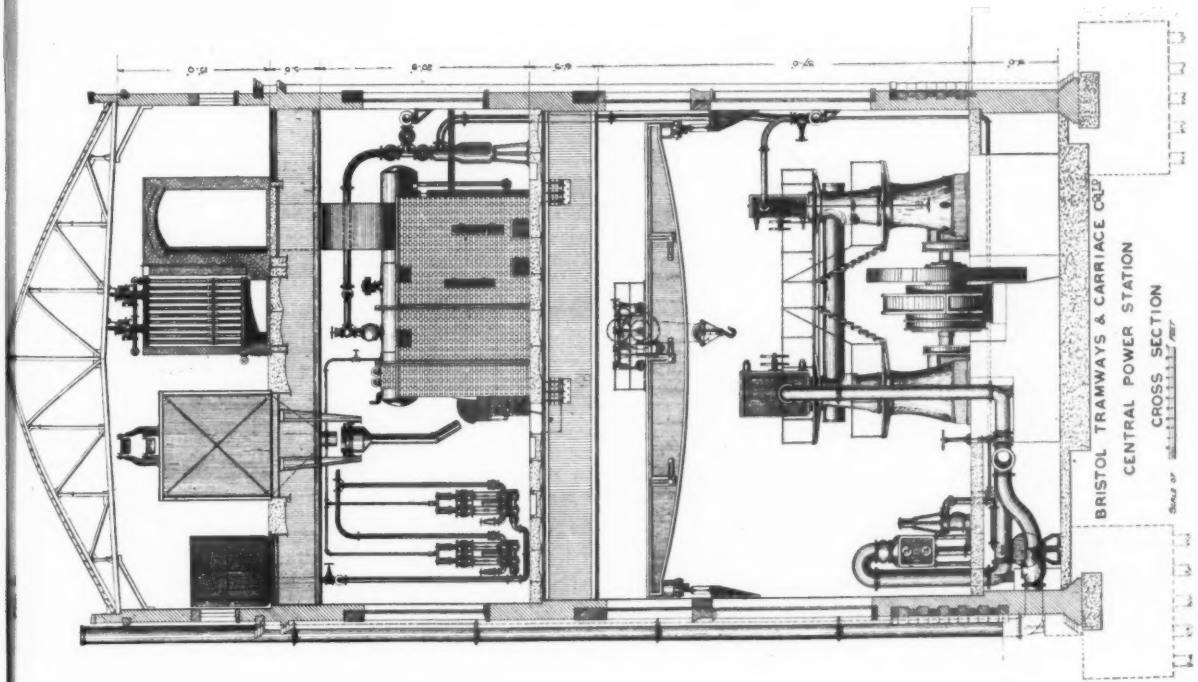


FIG. 7.—BRISTOL TRAMWAYS CENTRAL POWER STATION: FRONT ELEVATION.



The Ober-Spree and Moabit Stations are equipped with horizontal engines of 3,500 and 6,000 h.p. each, direct coupled to dynamos generating energy at 6,000 volts. Each is intended to be a 50,000 h.p. station. The buildings are faced externally with fine hard bricks, bright buff, laid in the German fashion, all headers. The gable ends are well treated with very large windows and strongly marked divisions in the lights. The general wall-faces are plain, but the header bond gives an excellent scale to the buildings, and the ornament is concentrated in a few well-designed and well-placed features by which the full value of the expenditure on embellishment is obtained. This is a much more effective and suitable treatment than expenditure on more expensive facing material, such as red bricks instead of ordinary building bricks, and the string courses and mouldings commonly used on what are called plain buildings. It is often said of buildings treated like Geneva, Munich, and the Berlin stations, that they are expensive. They are generally less costly than many buildings which look plain and are so described. The difference is that in the one case full value is obtained from the embellishments by good design, in the other case the same or greater expense is incurred for material not essential to construction frittered over the surface and therefore ineffective.

FIG. 8.—STEAM-POWER STATION, MUNICIPALITY OF MUNICH.

Of European central stations generally it may be said that the power station is rapidly superseding the direct supply station; but the older stations of Spain, Denmark, Greece, Belgium, Norway, and Sweden are still rather direct supply than power stations. The old station at Hamburg, in the Stadtmühlstrasse, may be mentioned as an uncommon arrangement, the engine room and battery rooms being one building, and the boiler house another, the steam pipes crossing under the street.

At the central station at Copenhagen there is a remarkably fine richly moulded and decorated timber roof over the engine room, of the usual Danish style. As a piece of carpenter's work it is both interesting and beautiful, but unsuitable for a central station. The central station is placed in the midst of a block of buildings, which is an undesirable position for a building of this kind. The roof is not only dangerous to the station, but also to the buildings round. It is fated to be burnt, unless soon removed, for timber in these buildings soon becomes as dry as tinder and highly inflammable. The engineer has realised the danger, and in the extensions of this station now in course of erection only incombustible materials are being used, similar to the construction now adopted in the best English and

foreign practice. The Russian stations, such as Moscow and Brakpan, are interesting in engineering details, but the buildings are unimportant.

Nearly every town of any size on the Continent now has a power station of some kind, and many extremely interesting buildings have been erected. The power station at Munich [fig. 8], with its interesting and original shaft [fig. 16, p. 310], the whole forming a most picturesque group with the baths which adjoin it. The station at Turin, with elegant gable treatment, and a circular brick shaft, well treated with pilasters and cornice at the top and plain brickwork below, partly water-power and partly steam, is an interesting example of Italian practice. At Vicenza, where a most ingenious arrangement of double arches and open tile-work is adopted for the windows.

As examples of effective interior treatment the station at Quedlinburg, in which the engine room is treated in plaster and brickwork, with black and white tile floor; Hof, in which the engine room is treated in brick and plaster, the latter decorated in colour, also with black and white tile floor; and Freiberg, as an example of simple and effective plaster treatment, may be cited. All these stations also exhibit much careful thought in the design of the elevations, which are in the characteristic style of the districts in which they are situated. They were designed by the Siemens-Schuckert Company. As an example of a somewhat elaborate Italian treatment the power station at Genoa, designed and equipped by the Allgemeine Company of Berlin, is interesting, and is indeed one of the finest stations in Italy.

Before leaving the subject of foreign power stations it is well to note that the arrangement of the plant substantially on one floor with coal store overhead is generally adopted wherever possible. The stations of the Detroit, Ypsilanti, Ann Arbor, and Jackson Railway, and at Grand Rapids for the Detroit Port Huron Railway, and the Toledo Fremont and Norwalk Railway, at Fremont, on the Sandusky River, all of the Westinghouse, Church, Kerr Company, are examples of this practice in the districts outside a city area in America.

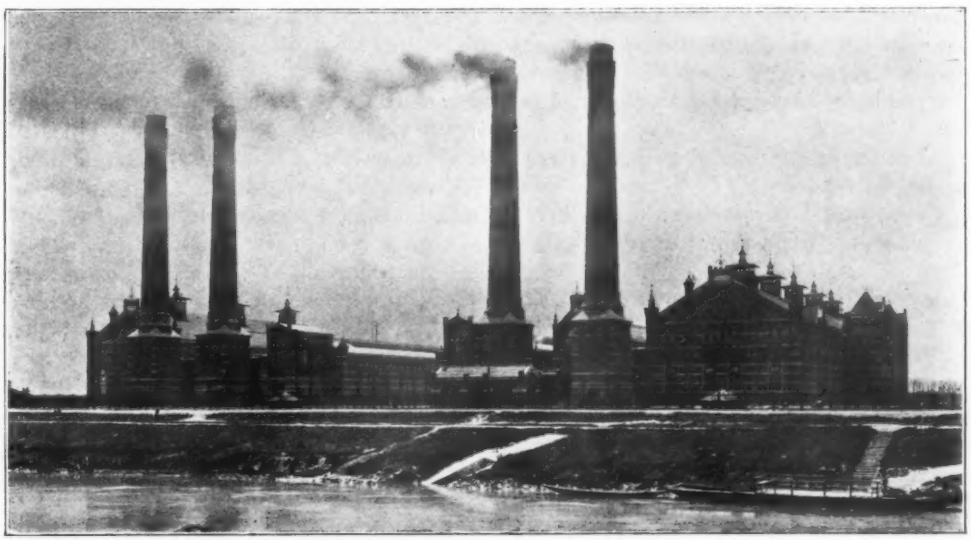


FIG. 9.—THE MUNICIPAL ELECTRIC POWER STATION, VIENNA.

The great power station of the Municipality of Vienna, designed and equipped by the Siemens-Schuckert Company, is one of the finest European examples [fig. 9, and pl. viii.].

Central stations without number could be cited did space admit, in which some novel architectural feature has been used as the direct outcome of the special requirement of the building.

Almost every combination and kind of plant and design of central station is to be found in Great Britain. This diversity of practice has added considerably to general knowledge about these buildings, but without thoroughly testing any type, as the uniformity of practice in other countries has done. Information collected from English practice is somewhat misleading, and false conclusions are often arrived at in consequence of being based on experience derived from one building, where perhaps exceptional circumstances have produced some result which is apt to be regarded as reliable, when in fact it is not. Many curious mistakes have arisen from this cause.

Some stations closely resemble American types, such as the power station now in course of erection on a site of 3½ acres at Lot's Road, Chelsea [pl. iii.], in connection with the electrification of the underground railways of London. The station has been designed by Mr. J. R. Chapman, chief engineer to the company. It has a frontage of 1,100 feet to the Thames and Chelsea Creek, 824 feet to Lot's Road. The building is 433 ft. 6 in. long, 175 feet wide, and 140 feet high from the ground floor to apex of roof.

The engine-house is a two-story building, and the boiler-house is a typical five-story type.

The building is steel skeleton frame, with central division wall and external screen walls between main steel supports. The elevations are faced with Fletton bricks, with red terra-cotta and red brick dressings.

The engine-room is 445 feet long, 72 ft. 6 in. wide, and 80 feet high from basement floor to top of lantern. The basement is 20 feet high. It will contain ten Westinghouse horizontal steam turbines, running at a speed of 1,000 revolutions per minute, coupled direct to three-phase generators, the current being generated at 11,000 volts, 33⅓ cycles. There is space in the engine-room for one additional machine half the size. The current is transmitted at this tension to twenty-three sub-stations. The switchboard is carried on three galleries at the north-east end; the condensing plant and steam-pipes are in the basement of the engine-room.

The boiler-house is 445 feet long, 96 feet wide, and 140 feet high from basement floor to apex of lantern.

The building is carried on heavy piers of masonry, carried down 29 ft. 6 in. below the basement level.

The boiler-house will contain eighty horizontal water-tube boilers, arranged in double rows on two floors, with automatic stoking. There are four circular brick shafts, each 19 feet internal diameter, 275 feet high. The foundations are 42 feet square, and the bottom of the concrete is 34 ft. 6 in. below the ground line. There are 2,200 cubic yards of concrete in each shaft foundation.

The coal store has a capacity of 15,000 tons, and it is estimated that 800 tons will be consumed daily.

The machinery will develop at normal load 76,500 h.p. (57,500 kilowatts).

The power station about to be erected by the Great Western Railway Company at Park Royal, near Acton, was designed by Messrs. Kennedy & Jenkin, consulting engineers, and the buildings by the architect's department of the Great Western Railway Company.

The site has an area of about twenty acres, with a frontage of 1,000 feet to Willesden Lane and 800 feet to Coronation Road. The present building is to be 260 feet long, about

100 feet wide; but it is contemplated that in the future it will be quite eight times this size.

The engine-house will be a one-story building, and the boiler-house one story high.

Skeleton steel framing will be used for the main construction, filled in with brick screen walls.

The engine-room is to be 120 feet long by 105 feet wide, by 50 feet high from the floor to top of lantern, with a basement 8 feet high. It will contain eight 1,200 i.h.p. Belliss three-crank vertical type engines, running at a speed of 250 revolutions per minute, coupled direct to Electric Construction Company's three-phase alternators, the current being generated at a tension of 6,500 volts, at which potential it will be transmitted to four sub-stations. The switchboard will be carried on a gallery at the east end.

The boiler-house is to be 140 feet long, 92 feet wide, 80 feet high from basement floor to apex of lantern. The bottom of the foundations will be 4 feet below basement floor, and rest on chalk subsoil.

The boiler-house will contain ten Babcock & Wilcox patent water-tube boilers, with self-contained super-heaters and automatic stoking. There is one octagonal brick shaft, 14 feet internal diameter, and the top 250 feet high above the level of the fire-bars. The foundations are 48 feet square by 9 feet thick, and rest on the chalk subsoil.

The coal store is placed over the boiler-house, and has a capacity of 8,000 tons. It is estimated that 150 tons will be consumed daily.

The machinery will be capable of developing about 10,000 h.p. (6,000 kilowatts).

Another important power station in connection with railways is that of the Metropolitan Railway now in course of erection at Neasden. The plant is all arranged on one floor; Westinghouse steam turbines directly coupled to generators of 3,500 k.w. each, giving energy at 11,000 volts, 3 phase $33\frac{1}{3}$ cycles per second, are being installed.

One of the largest power houses in London will eventually be that of the Central Electric Supply Company at Grove Road, St. John's Wood [see frontispiece and pl. i., ii.], which will supply power for general purposes for the west-end districts of London served by the Westminster Electric Supply Corporation and St. James's and Pall Mall Electric Lighting Company. It is situated on the banks of the Regent's Canal, the site being $7\frac{1}{2}$ acres in extent, all of which will eventually be covered with the buildings. Upwards of 150,000 h.p. can be placed on the site if the plant is arranged on the one-floor system. The one half of the first section has recently been completed, and provides accommodation for 14,800 h.p.

The steam generator adopted (of which each section will contain 28) is known as the Climax Boiler. It is a new kind of vertical water-tube boiler. It occupies a very small area of ground space, and has so far proved efficient.

The chimney shafts (there will eventually be six) are very prominent structures, and standing high can be seen for a considerable distance in all directions. Each shaft is 18 ft. by 18 ft. inside measurement at the top, 260 ft. high from top of concrete to top of cap. The main flues enter by three openings 60 ft. above ground level. In the architectural treatment of the upper part an attempt has been made to take advantage of the iron bands which sooner or later are required round the upper part of all shafts, and of the recesses formed, by placing the set-offs, when the brickwork is reduced in thickness, on the outside instead of the inside of the wall. By these means some relief is obtained, and the upper part is designed as an enriched feature which, in contrast with the plain wall below, forms the whole composition. It is possible that working on these lines some satisfactory and characteristic treatment of large stacks may be evolved. Similar principles have been followed in the general treatment of the principal façades. The flues are built of double casings of steel plates with air space

between them, and are carried outside above the roof of the boiler house, and are free to expand and contract. There will be four blocks of buildings. Each block will contain an engine room 110 feet by 224 feet by 66 ft. 6 in. high from engine room floor to top of lantern. This room will accommodate ten vertical high-speed engines direct coupled to dynamos of 2,400 h.p., three of 1,200 h.p., and three of 300 h.p., or 28,500 h.p. in all. The current is generated at a tension of 6,000 volts. The switchboard is on a gallery at one end of the engine room, which is continued round the room to give access to the high level platform of engines. The building is skeleton steel construction, with substantial external walls. Messrs. Kennedy and Jenkin and S. T. Dobson are the engineers, and Messrs. C. Stanley Peach and C. H. Reilly the architects.

The principal power station in Edinburgh is at McDonald Road, Leith Walk [fig. 10]. It was designed by Messrs. Kennedy and Jenkin, engineers, the Burgh engineer, Mr. Cooper, being the architect. The site has an area of three acres, with a frontage of 540 feet to McDonald Road. The present building is 270 feet long and 110 feet wide; but it is contemplated that in the future it will be quite four times this size.

The engine house is a one-story building, and the boiler house is one story high, with overhead coal bunkers.

Skeleton steel framing has been used for the main construction, filled in with brick screen walls. The elevation is faced with stone.

The engine room is 120 feet long by 70 feet wide, by 66 feet high from the floor to top of lantern, with a basement 8 feet high. It will contain eight 1,200 i.h.p. three-crank vertical Willan's engines, running at a speed of 230 revolutions per minute, coupled direct to

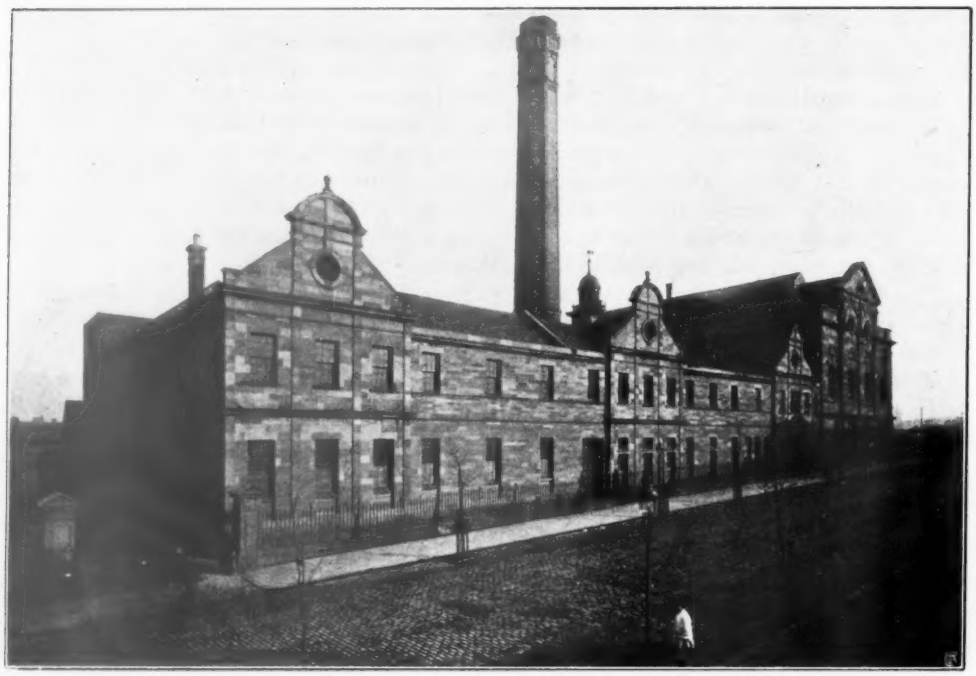


FIG. 10.—POWER STATION OF THE CORPORATION OF EDINBURGH, MCDONALD ROAD, EDINBURGH.

continuous current shunt-wound Mather and Platt and Siemens dynamos, the current being generated at a tension of 480 volts. The switchboard is carried on a gallery at the south end.

The boiler house is 195 feet long, 60 feet wide, 44 feet high from basement floor to apex of lantern. The bottom of the foundations is 4 feet below basement floor, and rests on sand subsoil.

The boiler house contains 19 dry back marine type Sinclair and Stewart boilers, with automatic stoking. There is one octagonal brick shaft, 11 ft. 6 in. internal square, and the top 250 feet high above the level of the fire-bars. The foundations are 40 feet square by 8 feet thick, and rest on the sand subsoil.

The coal store is placed over the boiler house, and has a capacity of 1,300 tons. It is estimated that 60 tons will be consumed daily.

The machinery will be capable of developing about 10,000 i.h.p. (6,000 k.w.).

One of the principal power stations of the Corporation of Glasgow is at Port Dundas, opened in September, 1900. It is rather a direct supply than a power station. About one-third has been erected. It will eventually accommodate plant of 30,000 i.h.p. Mr. W. A. Chamen was engineer.

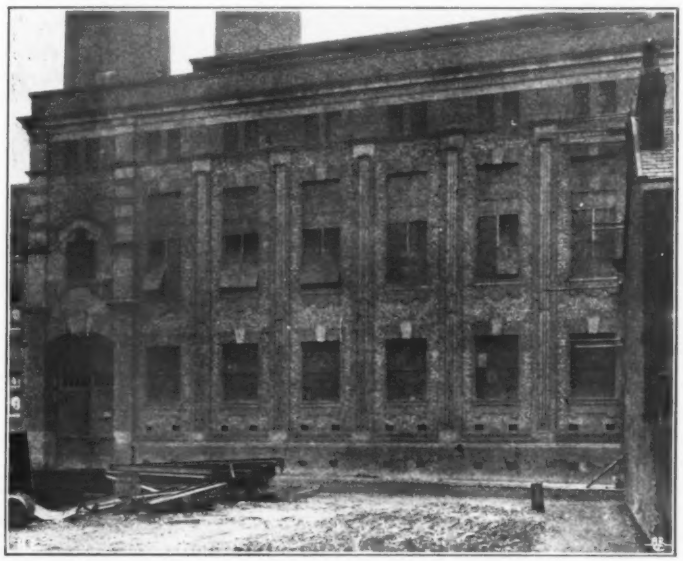


FIG. 11.—POWER STATION OF THE CORPORATION OF MANCHESTER, STUART STREET.

The principal power station of Manchester is situated at Stuart Street [fig. 11, and pl. iv.], and was designed by Messrs. Kennedy and Jenkin, consulting engineers, Messrs. C. S. Allott and Sons being the architects.

The site has an area of 8 acres, with a frontage of 550 feet to Stuart Street. The present building is 320 feet long, 140 feet wide; but it is contemplated that in the future it will be quite four times this size.

The engine house is a one-story building and the boiler house is two stories high, with coal store over the boilers.

Skeleton steel framing has been used for the main construction, filled in with brick screen walls. The elevation is faced with Ruabon bricks with stone dessings.

The engine room is 115 feet long by 130 feet wide, by 70 feet high from the floor to top of lantern, with a basement 12 feet high. It will contain six main 2,400 i.h.p. Yates and Shaw engines, running at a speed of 94 revolutions per minute, coupled direct to electrical three-phase alternators, the current being generated at a tension of 6,500 volts, at which potential it is transmitted to ten sub-stations. The switchboards are carried on four galleries at the west end.

The boiler house is 205 feet long, 92 feet wide, 64 feet high from basement floor to apex of lantern. The bottom of the foundations is 4 feet below the basement floor, and rests on clay subsoil.

The boiler house contains 24 Babcock and Wilcox patent water-tube boilers, with automatic stoking. There are two (octagonal) brick shafts, 12 feet and 16 feet square (inside), and the tops 200 and 250 feet respectively, above the level of the fire-bars. The foundations are 48 feet square by 9 feet thick, and rest on the clay subsoil.

The coal store is placed over the boiler house, and has a capacity of 700 tons. It is estimated that over 100 tons will be consumed daily.

The machinery will be capable of developing about 15,000 h.p. (9,000 k.w.).

A noticeable feature in the design of this building is the treatment of the steel construction. The main stanchions are not covered, but are exposed in the elevations; the brickwork between them being shown as a curtain, and treated as it really is, panel work between the main supports.

The power station of Sunderland is situated at Farringdon Row, Hylton Road, and was designed by Mr. John F. C. Snell, Borough Electrical Engineer, who was also the architect.

The site has an area of three acres, with a frontage of 675 feet to Farringdon Row. The present building is 167 feet long, 113 feet wide, 53 feet high from ground floor to apex of roof; but it is contemplated that in the future it will be quite three times this size.

The engine house is a one-story building, and the boiler house is one story high. The elevation is faced with Sherburn bricks, and with stone dressings.

The engine room is 164 feet long by 44 feet wide, by 45 feet high from floor to top of lantern, with a basement of 7 feet high. It contains eight triple expansion, surface condensing Belliss & Morcom engines, running at a speed of $\frac{250}{325}$ revolutions per minute, five being coupled direct to Silvertown direct current dynamos, and three, each of 1,100 b.h.p. coupled direct to a.e.g. three-phase alternators, the current being generated at a tension of 5,500 volts, at which potential it is transmitted to four sub-stations. The switchboard is carried on a gallery situated at the east side of the engine room, in a position which will be ultimately central with the completed station.

The boiler house is 164 feet long, 63 feet wide, 49 feet high from basement floor to apex of lantern. The bottom of the foundations is 4 feet below the basement floor, and rests on boulder clay subsoil and magnesian limestone.

The boiler house contains eight Lancashire and Galloway 30 feet by 8 ft. 6 in. diameter boilers, with automatic stoking, superheaters, and Green's economisers.

There is also a motor-driven induced draught fan.

There is one octagonal brick shaft, 8 feet internal diameter at the top, 115 feet high above level of the fire-bars. There will ultimately be two such shafts.

The foundations are 28 feet square by 21 feet thick, and rest on the magnesian limestone subsoil.

The coal store is placed in the upper part and to one side of the boiler house, and has a capacity of 280 tons; it is estimated that forty tons will be consumed daily by present plant.

The machinery is capable of developing 5,200 horse-power (3,530 k.w.).

The power station of the County Borough of Brighton is situated on the south side of the east arm of Shoreham Harbour (Southwick), and was designed by Mr. Arthur Wright in conjunction with Mr. P. F. Lapworth and Mr. T. G. Otley.

The site has an area of over ten acres, with a frontage of 679 feet to Shoreham Harbour, and 719 feet facing on the beach.

The present building is 247 ft. 3 in. long, 229 ft. 6 in. wide, and 65 feet high from ground floor to apex of roof; but it is contemplated that in the future it will be about twice this size.

The engine house is a one-story building, and the boiler houses are also one story high. Skeleton steel framework has been used for the main construction, filled in with brick screen walls. The elevation is faced with red bricks with stone dressings.

The engine room is 220 feet long by 74 feet wide by 65 feet high from floor to apex of roof, with a basement 15 feet high. It will contain nine 1,800 k.w. steam turbines, running at a speed of 1,500 revolutions per minute, coupled direct to three-phase alternators, the current being generated at a tension of 8,000 volts, at which potential it is transmitted to the North Road sub-station, Brighton. The switchboard is carried on a gallery at the north end of the engine room.

The boiler houses are each 228 feet long, 73 ft. 10½ in. wide, and 50 feet high from firing floor to apex of lantern.

The bottom of the foundations of the structures is in some cases about 31 feet below the engine room floor, and rests on a blue clay subsoil.

The boiler houses will contain eighteen water-tube boilers, each having 6,000 square feet tube-heating surface, together with six superheaters (separately fired) all provided with mechanical stokers.

There are four circular steel shafts, each 6 feet internal diameter at the top, and about 100 feet high above level of the fire-bars, used in conjunction with induced draught fans.

The chimney foundations are 14 feet square by about 31 feet deep, and rest on the blue clay subsoil.

The coal store is placed over the boiler house, and has a capacity of about 3,000 tons; it is estimated that 80 tons will be consumed daily when all the plant is installed in the present first section.

The machinery will be capable of developing about 14,400 kilowatts.

The power station of Eastbourne is situated at Roselands Seaside, and was designed by Messrs. Brydges and Hawtayne, engineers, Mr. R. M. Gloyne being architect. The site has an area of 11,483 square feet.

The present building is 119 feet long, 96 ft. 6 in. wide, 52 feet high from the ground floor to apex of roof, and is about one-third of future size. It is a brick building of consistent fireproof construction throughout.

The engine room is 82 feet long, 35 feet wide, 45 feet high from the floor to top of lantern, with a basement 7 feet high. Five vertical engines, direct coupled to Ferranti and Electric Construction Company's dynamos, are at present installed. Energy is generated at a tension of 2,200 volts, at which potential it is transmitted to twenty-two sub-stations. The switchboard is placed on a raised platform at one end of the engine room.

The boiler house is 92 feet long, 42 feet wide, 46 feet high from basement floor to apex of lantern. It contains six boilers. The bottom of the foundations is 7 ft. 6 in. below the basement floor, and rests on blue clay.

The shaft is circular, 7 feet internal diameter at the top, 150 feet high above level of fire-bars. It is built of brick, and the foundations are on the blue clay.

The coal store is parallel with the boiler house.

The plant at present installed is capable of developing 2,000 h.p.

The power station of Liverpool is at Lister Drive. Mr. A. Bromly Holmes is engineer; Mr. T. Shelmerdine is architect.

The site has an area of 14¼ acres, the longest frontage, 650 feet, being to Lister Drive. Building No. 1 is complete, and is 248 feet long, 165 feet wide, and 62 feet high from ground line to apex of roof.

Building No. 2 will be 440 feet long; about half has been erected.

The engine room is a one-story building 224 ft. 9 in. long, 52 ft. 4 in. wide, and 58 feet high from the floor to top of lantern, with a basement 10 feet high. It contains twelve Willans and Robinson high-speed vertical engines, 1,200 h.p. each, 230 revolutions per minute. The dynamos are direct coupled to engines, and generate energy at a tension of 460 to 550 volts for tramway and lighting services. A portion is generated at 6,000 volts.

The switchboard is in a switch room at the front of the building.

Each boiler house is a two-story building 100 feet long, 51 ft. 7½ in. wide, and 56 feet high from basement floor to apex of lantern. Each boiler house contains fourteen Lancashire boilers with automatic stokers arranged in two rows with central stoking passage.

There are two octagonal brick shafts, 13 feet internal diameter at top, about 200 feet above level of fire-bars. The foundations are 35 feet square and 8 feet thick, and rest on hard red clay.

The coal store is over the boilers, and has a capacity of 1,000 tons. It is estimated that 200 tons will be consumed daily.

The present machinery is capable of developing about 14,400 h.p. (9,600 k.w.).

The buildings are faced with red pressed bricks with red stone dressings.

The power station of the Dublin Corporation is situated at Pigeon House Fort [fig. 12 and pl. v.], on a breakwater at the side of the harbour, 1½ miles from the shore. It is a very complete

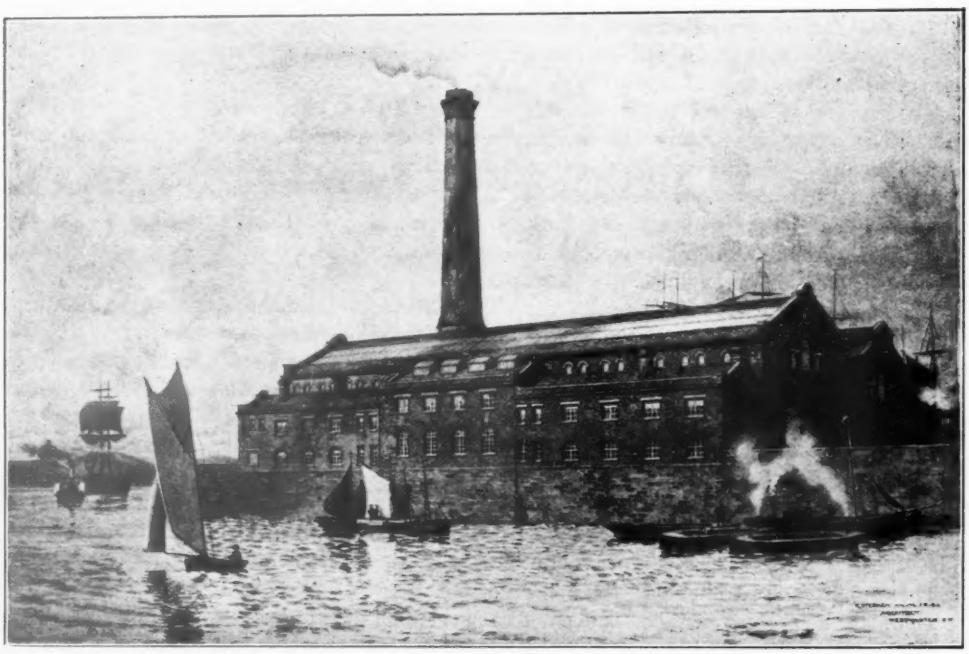


FIG. 12.—POWER STATION OF THE CORPORATION OF DUBLIN AT PIGEON HOUSE FORT.

station, with plant arranged substantially on one floor, with boilers back to back with the engines. There are six 30 feet by 8 ft. 6 in. Lancashire boilers (cylindrical), and four Babcock & Wilcox horizontal water-tube boilers, set in batteries of two each. The boiler house is fitted with mechanical stokers for feeding coal to the boilers from an overhead coal store, and a conveyor for removing the ashes. The boiler house is 153 feet by 53 feet by 31 ft. 6 in. from floor to springing of roof.

The chimney shaft is octagonal, standing on a brick base 20 feet square, constructed of brick. It is 186 feet high, with an internal diameter of 9 feet. The concrete foundation is 36 feet by 36 feet by 12 feet thick, resting on piles 24 feet long.

The engine room, which is 153 feet by 50 feet by 37 feet from floor to springing of roof, contains two Oerlikon 1901 pattern generating sets of 1,000 k.w., and two of 500 k.w. capacity, direct coupled to 820 h.p. vertical Corliss compound engines. The fly-wheels are 14 feet diameter, 28 inches wide, and weigh 29 tons, and run at a normal speed of 94 revolutions per minute. The current is generated at 5,000 volts, with a frequency of 50 cycles per second. The larger engines are a similar type, but 1,620 i.h.p.; the fly-wheel is 18 feet diameter by 2 ft. 6 in. wide, and weighs 40 tons, and runs at a normal speed of 83⅓ revolutions per minute. It is a condensing station. The engineer is Mr. Robert Hammond; and Mr. Stephen Ayling is the architect.

Ringsend power house in Dublin belongs to the Dublin United Tramways Company, and is situated on the Grand Canal Basin, Ringsend, and supplies power for the tramways throughout the city. It is partly a direct supply station and partly a power station, supplying substations at Blackrock, Dalky, and Clontarf.

The electric current generated is three-phase, at a tension of 2,500 volts. There are at present 5 direct-current generators, and one three-phase generator in the station.

The building is 180 feet long by 160 feet wide, the engine room being 80 feet wide and 62 feet high from basement to roof, and 34 feet high from engine room floor to wall plate. The boiler house is 62 feet wide and 66 feet high inside measurements, and contains 20 Babcock and Wilcox boilers, arranged in two rows of ten each—twelve at present installed. The building is of skeleton steel construction enclosed with brick screen walls, the whole resting on concrete foundations. There is an overhead coal store of 1,500 tons capacity—mechanical stokers.

The chimney shafts are steel, brick-lined, 230 feet high, having an internal diameter of 10 feet inside the lining. Condensing plant in basement.

The switchboard gallery is 16 feet above the engine room floor. The engine room is designed to contain 10 units arranged in two rows. Of these, six are already installed. The engines are vertical cross compound Allis, having fly-wheels 19 feet diameter, and weighing 19 tons, running at 90 revolutions per minute, and are direct-coupled to General Electric Company's generators. Five are multipolar direct current type of an output of 550 k.w. at 90 revolutions per minute, with 50 per cent. overload. The sixth is a three-phase generator of revolving field type, also 550 k.w. at 90 r.p.m.

The station of the London United Tramways, at Chiswick [fig. 13], is a building of distinct individuality, and the elevations are impressive. The engineer is Mr. Parshall, Mr. Curtis Green the architect.

The power house is 154 feet by 106 feet, and both engine room and boiler house are faced externally with red brick and Portland stone, and internally with glazed bricks. Steel shaft 300 feet, and 10 feet internal diameter inside the fire-brick lining. It stands on a cast-iron base plate, supported on a pedestal of red brick with Portland stone dressings. The flue enters 30 feet above ground.

The power station of the City of London is situated on the south side of the Thames,

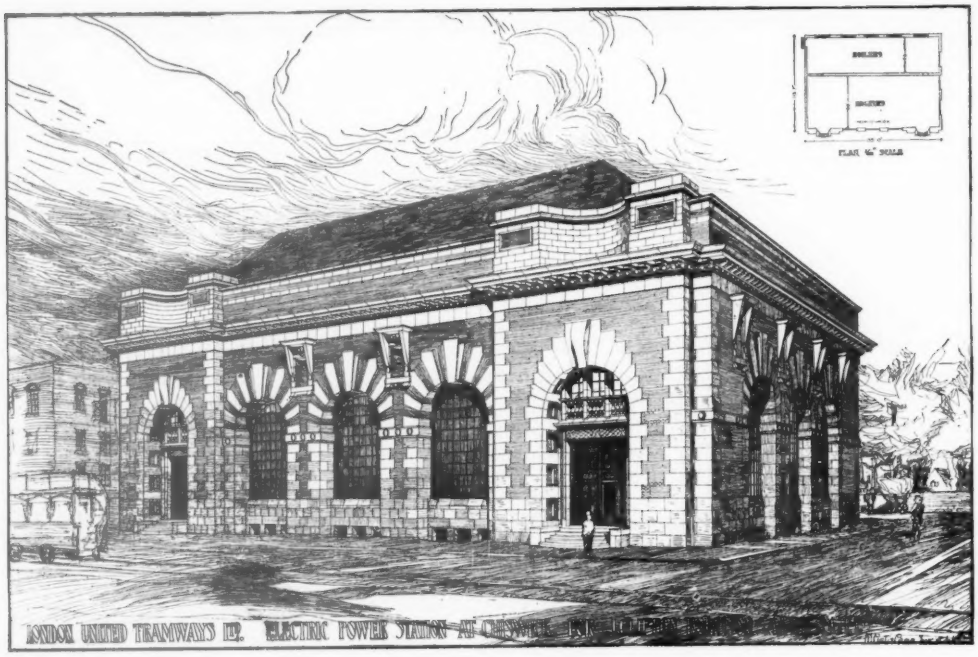


FIG. 13.—CHISWICK ELECTRIC-POWER STATION.

close to Blackfriars Bridge. The erection was commenced in 1892, and several enlargements have been made since. It is a very remarkable and interesting station, of over 14,500 h.p., but is unique in so many respects that no short description is possible. It is very fully described in the *Electrical Review* of March 3, 10, and 17, 1899, and February 28, 1902. There are three engine rooms, two boiler houses, and three shafts. It is partly a power and partly direct supply, but is in every way a notable example of a large installation. Although the land is extremely valuable, the one-floor arrangement has been adopted, which has proved both convenient and economical in working. It was designed by Mr. Frank Bailey.

There are numbers of other steam power stations, all presenting many features of interest, but the examples described are sufficient to indicate the general features of this class.

DIRECT SUPPLY STATIONS.—SIMPLE.

The simple direct supply station consists of the machinery departments somewhat on the same lines as the power station, of which it was the forerunner.

The Mason's Yard Central Station of the St. James's and Pall Mall Electric Light Company, Limited; Manchester Square, of the Metropolitan Electric Lighting Company; Chapel Place, of the Kensington and Knightsbridge Electric Light Company; Wandsworth, of the County of London and Brush Provincial Electric Lighting Company; the Central Stations of Battersea; Shoreditch (Whiston Street); of the respective Borough Councils, and the station

of the London County Council on the Thames Embankment, amongst many others, are examples of this class in London.

It was almost the earliest form of station, and originated simultaneously with the composite form of direct supply station. It was required in those districts which were too large to be served by one central station, before the days of the power station. It is not probable that many more of these stations will be required. Some of the existing simple direct supply stations are already being converted into sub-stations, and in time, no doubt, the steam plant will be taken out of many, and be replaced with electrical machinery only.

The Continental stations of this class are in many respects so similar to English examples that no detailed description is necessary; but the construction and elevations naturally possess the architectural features of the country to which they belong. As a comparatively obsolete class it would serve no useful purpose to give fuller particulars about them.

DIRECT SUPPLY STATIONS.—COMPOSITE.

Of the composite type of direct supply stations numbers exist all over the world. In small towns, in the country remote from other towns or from centres where power can be generated under exceptionally favourable conditions, and in agricultural districts, no doubt many of this type will be erected for some years to come. Sooner or later, however, combination between towns and districts will take place, and co-operative power stations will replace this class also, and those then existing will become at any rate partly sub-stations also. It will be a great advantage to this country in the keen war of trade competition which is before it, and will reduce the appalling extravagance and waste of the mineral wealth of this country which is now going on from the unnecessary consumption, carriage, and handling of coal, and all the attendant waste of land, labour, and time, and congestion of traffic produced and fostered by present methods. Unfortunately, the day has not yet come, and so composite stations will still be wanted, and a few notes on them will be useful.

They are in fact complete electrical works generating and distributing energy and include accommodation for all departments connected with the industry.* A complete composite station contains the following accommodation:—

Machinery Department.—Engine house, for engines, dynamos, switchboard, leads from dynamos and mains leaving the station, condensing plant, watch engineer's office, and accommodation for engine room staff and drivers. Workshop, oil and waste stores, engine room stores.

Electrical Storage Department.—Battery-room and stores.

Steam Department.—Boiler house and overhead coal store, economiser house, chimney shafts, pump room, and feed tanks. Accommodation for stokers, mess room, dressing room and lavatories, w.c.'s, &c., boiler house stores. Coal siding and elevator and conveyor, and hoist and truck way.

Water Department.—Similar to the power stations.

Tramways Department.—Car shed, painting shop, workshop in common with the machinery department, sand store, lamp room, car drivers' room, mess room, dressing rooms, lavatories, and w.c.'s for tramway staff.

In some cases where condensing water is not drawn direct from the river, cooling and water-softening plant is generally installed.

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* Plans and sections of many of these stations are exhibited. Among them Hackney and Islington, of the Borough Councils of these parishes; Ipswich, Kilmarnock, Kirkcaldy, Harrow, Calcutta.

Public Health Department.—Destructor for town refuse connected to same stack as electricity works. The steam generated therein is used for warming buildings or other small and unimportant work. It has not proved very successful as a steam generator for large engines.

Outside Mains and Public Lighting.—Cable stores, building materials stores, ladder and truck stores, arc lamp stores, general stores, and yard. Tools and plant stores, carpenter's shop, smith's shop and forge. Accommodation for workmen.

Meter Department.—General workshop, clockmaker's shop, tested meter stores, battery and meter testing room, calibrating room, photometer room, control offices, accommodation for staff.

Administration.—General public offices, board room or committee room, offices for general managers, accountant, collectors, meter clerks and readers, chief engineer's drawing office, lavatories, &c. for staff. Each department would require a timekeeper's office, but this can in many cases be combined for several. Sometimes a residence for engineer.

The accommodation, of course, varies in nearly every case, but this table of accommodation gives a general idea of the buildings constituting a central station or electricity works of this class.

A very complete station of this class has recently been erected by the Corporation of Ipswich [pl. xix., xx.], and there are many fine examples in the provinces.

In the full description of power stations many points applicable to central stations generally have been noted. These apply in a great measure to direct supply stations also. Within the limits of these notes it is not possible to give further details of this class.

SUB-STATIONS.

Sub-stations to accommodate static transformers have been in existence for many years. They were formerly small unimportant structures, frequently vaults under the pavement or roadways, or in basements of houses. The modern sub-station, however, is a very different thing. It is a building requiring careful design and of daily increasing importance. The function of the plant installed in it is either to alter the character or to reduce the tension of energy derived from the power stations, and to distribute either the same energy at another potentiality or to generate and distribute new energy at low tension by means of dynamos directly coupled and driven by motors. These compound machines are called motor generators.

It may be said that these stations use electricity as the source of power, but obtain it at present in an indirect manner. From the architect's point of view it is not very material whether the current flows through the machines and is transformed, or whether it is actually generated by motors driving dynamos. In ordinary running, motor generators do not cause much vibration; under certain conditions, however, very severe vibration is set up, but it is an accidental rather than a normal condition. Some types produce a peculiar and penetrating note.

A sub-station without batteries consists of one principal room in which the motor generators are placed, also the switchboards regulating the incoming and the outgoing currents, and the subways or chambers for the mains into and out of the building. An office for the engineer in charge and on duty, and lavatories and conveniences for staff, and some space for stores. The switchboards are usually placed on galleries.

The sub-station at Bennett Street, Manchester; Duke Street, Mayfair, London [figs. 14 and 15, and pl. xii.].

The addition of a battery makes a considerable difference to the design, as the batteries are often very large and require considerable room. Sometimes the building is only one story high, as sub-station No. 6 of the Manhattan Railway Company, which is a common type of American design; or it is a building of several floors, a more common Continental practice. The sub-station of Vienna of the Siemens-Schuckert Company; the sub-station Königin

FIG. 14.—MODEL OF THE ENTRANCE PAVILION OF THE 14,000 H.P. SUB-STATION OF THE WESTMINSTER ELECTRIC SUPPLY CORPORATION, LTD., DUKE STREET, MAYFAIR, LONDON.

Augustastrasse at Berlin of the Allgemeine Company; the Albert Hall station of the Kensington and Knightsbridge Electric Light Company, one of the first in London, of which Mr. H. W. Miller was the engineer, are a few examples.

Sub-stations must be placed fairly near the centre of the area which they supply. Sometimes they must be erected in fashionable quarters, in residential districts, or close to important buildings. Every precaution should be taken to prevent transmission of mechanical vibration, or escape of sound beyond the building. The buildings must be dry, well ventilated, and well lighted in every part. In many cases the amount of energy required for the district to be served by the sub-station can be closely estimated before the building is erected.

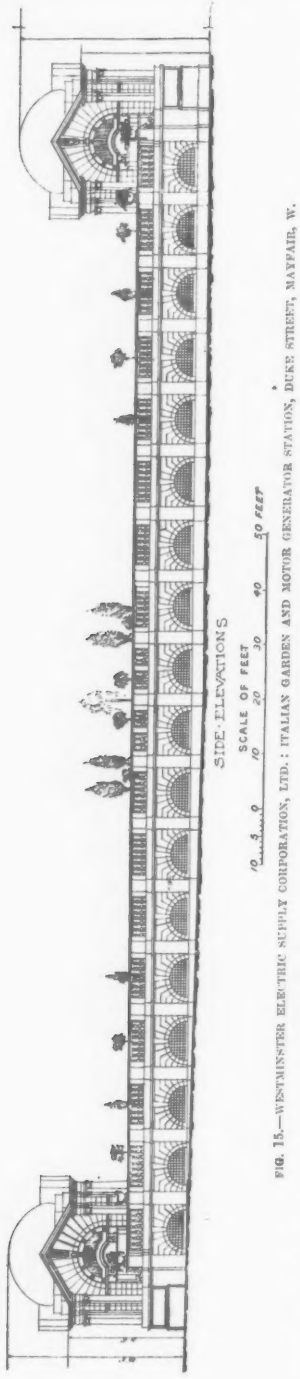


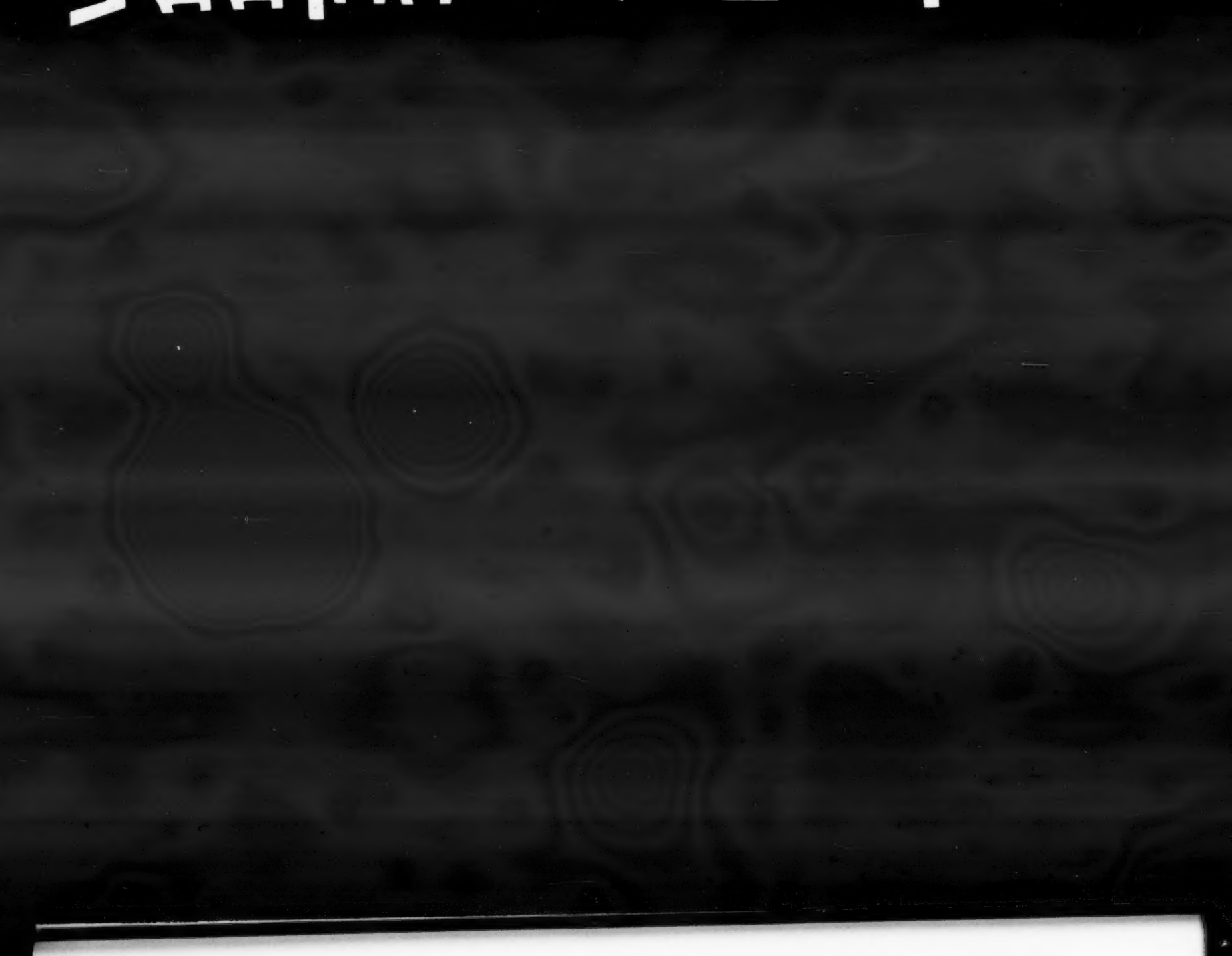
FIG. 15.—WESTMINSTER ELECTRIC SUPPLY CORPORATION, LTD.: ITALIAN GARDEN AND MOTOR GENERATOR STATION, DUKE STREET, MAYFAIR, W.

They will therefore generally be erected of full size at once, instead of being constructed as small buildings in the first instance adapted for enlargement in the future, as other central stations necessarily must be. To some extent this simplifies the design, but as these stations are of comparatively recent origin the kind of building likely to prove most suitable is not so well known, and present practice will no doubt be considerably improved. Hitherto they have been fairly small buildings, from 1,000 to 10,000 h.p., but they will probably be much larger in the future. Already sub-stations of 15,000 to 25,000 h.p. are projected, and some of this size are in course of erection. In future stations switchboards will perhaps be almost part of the structure, and the mains chambers will be separate from the machinery rooms. Indeed, more complete separation and greater space for mains than is usually allowed in this most important department are desirable in almost all classes of central stations, for there is no doubt that the switchboard is the most dangerous part of the installation.

Notes on central stations would hardly be complete without some reference to the chimney shafts. So important are these structures, and so interesting many details concerning them, that many pages would not exhaust all that should be noted about them. The breakdown of a shaft completely disables a central station, therefore there should not be less than two, and each should be capable of doing more than half the work of the station (or the division of the plant which it serves), so that, in case of necessity, one could, by being overworked for a time, take up a considerable portion of the work performed by the other shaft under normal working conditions.

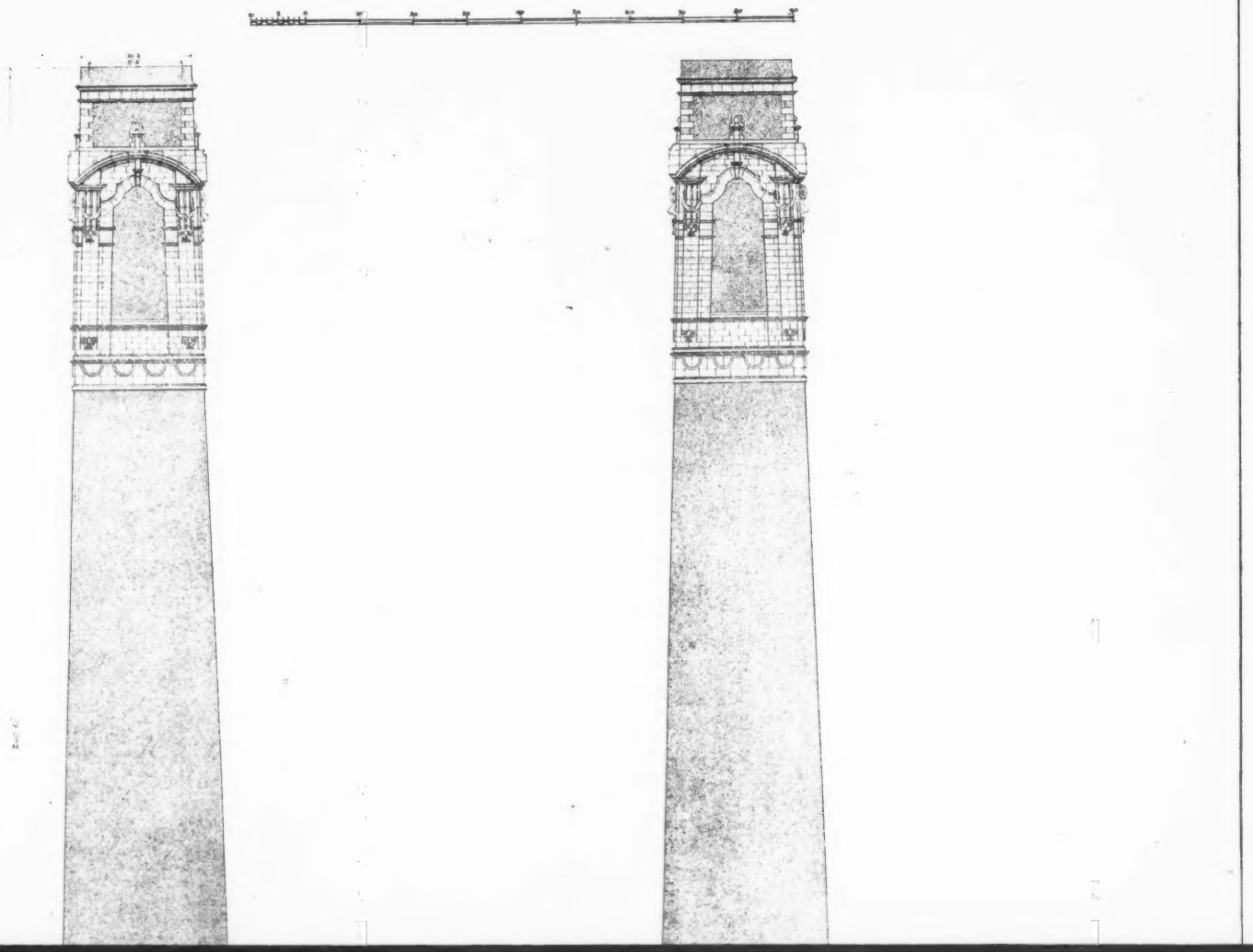
These shafts are not ordinary factory chimneys. Their importance to the undertaking, and consequently to the community, their great size, and the fact that they may be erected in groups of from two up to six or more, require that they should be of better construction and appearance than is often deemed sufficient. If an ordinary factory chimney, creating draught for perhaps 1,000 or 1,500 h.p., is disabled, one factory is inconvenienced or perhaps stopped for a few days while some temporary arrangements are made. But temporary arrangements to replace a 15,000 or 20,000 h.p. stack would take a considerable time; meanwhile the work, light, and traffic of a whole district might be completely disorganised.

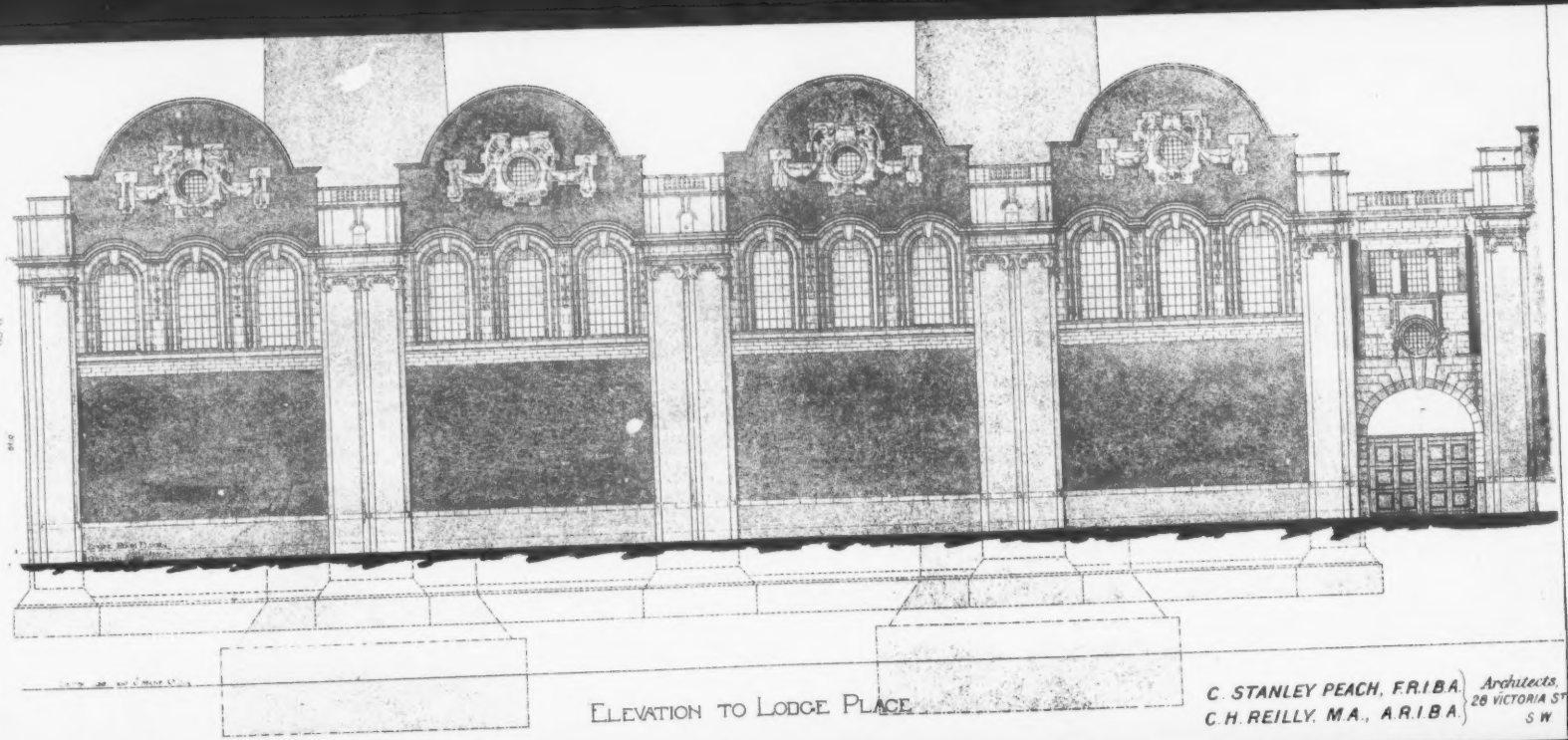
Many things are accepted as reliable facts about chimney shafts which rest on no better foundation than oft-repeated statements of workmen. It is a common belief that chimney shafts oscillate in a gale, and that if they do not they are deficient in elasticity, and are likely to be blown down. The results of actual measurements and observations of some hundreds of chimney shafts prove that they do not oscillate or sway, and



THE CENTRAL ELECTRIC SUPPLY COMPANY LIMITED.

GROVE ROAD STATION MARYLEBONE, N.W.

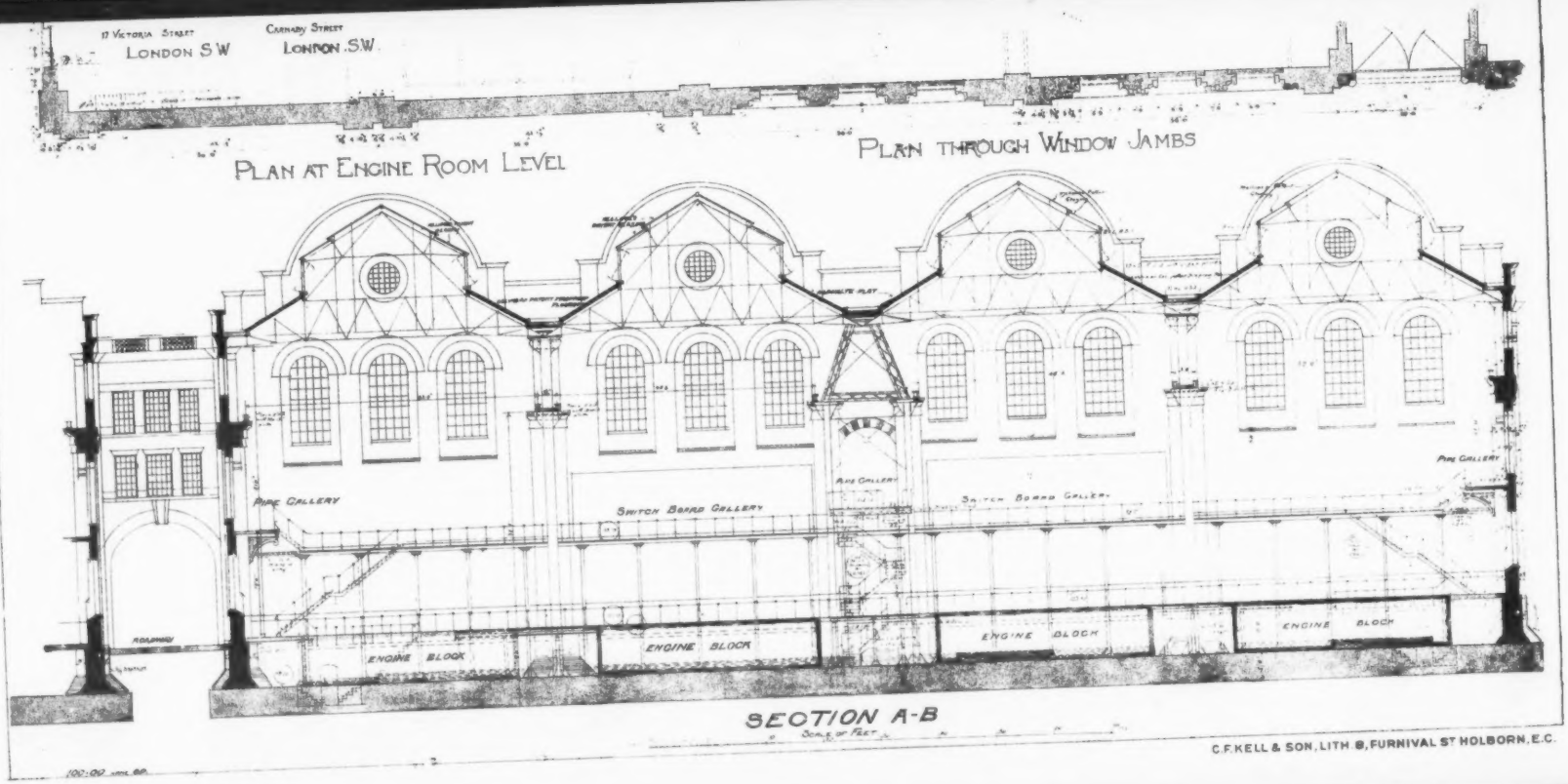


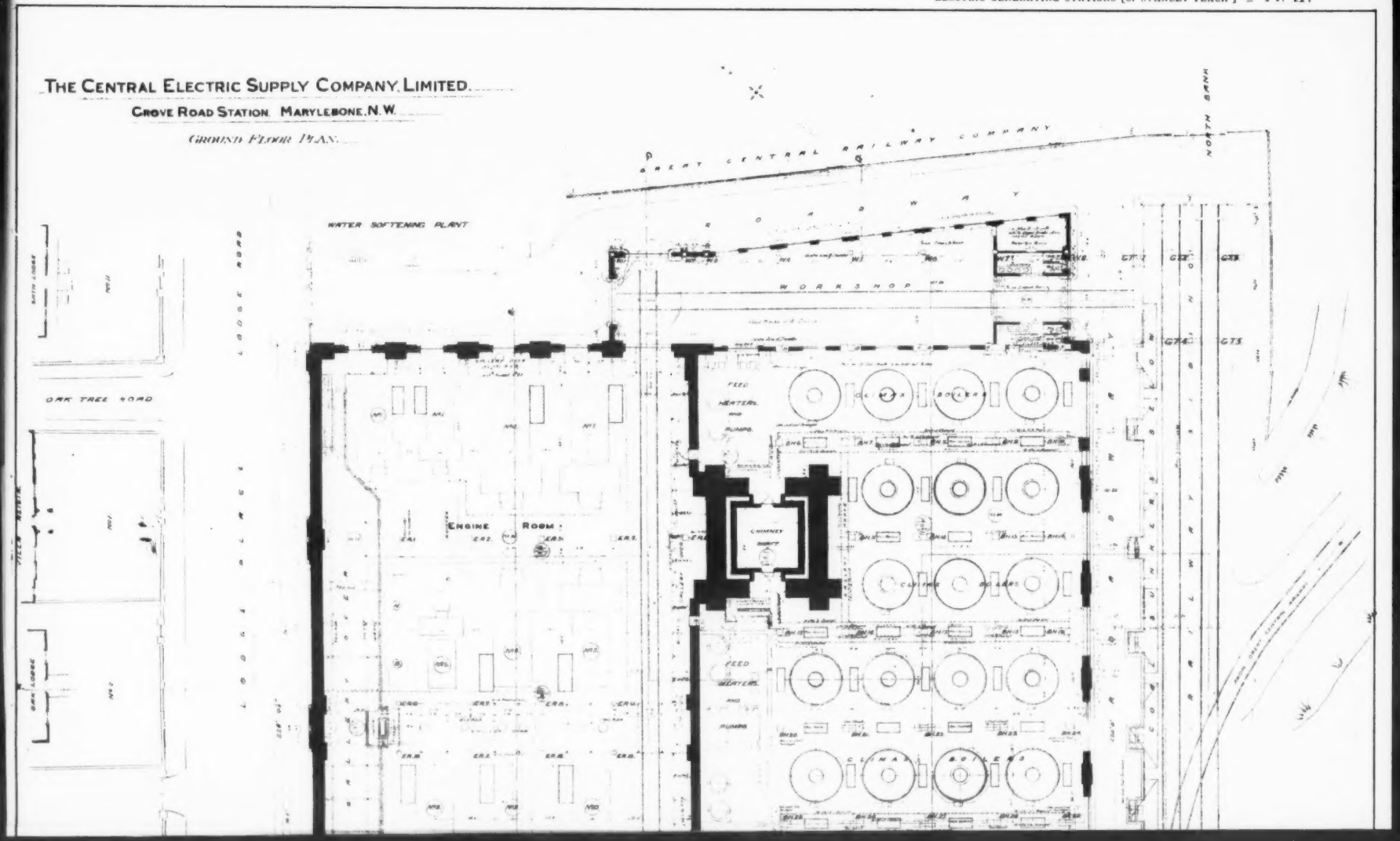


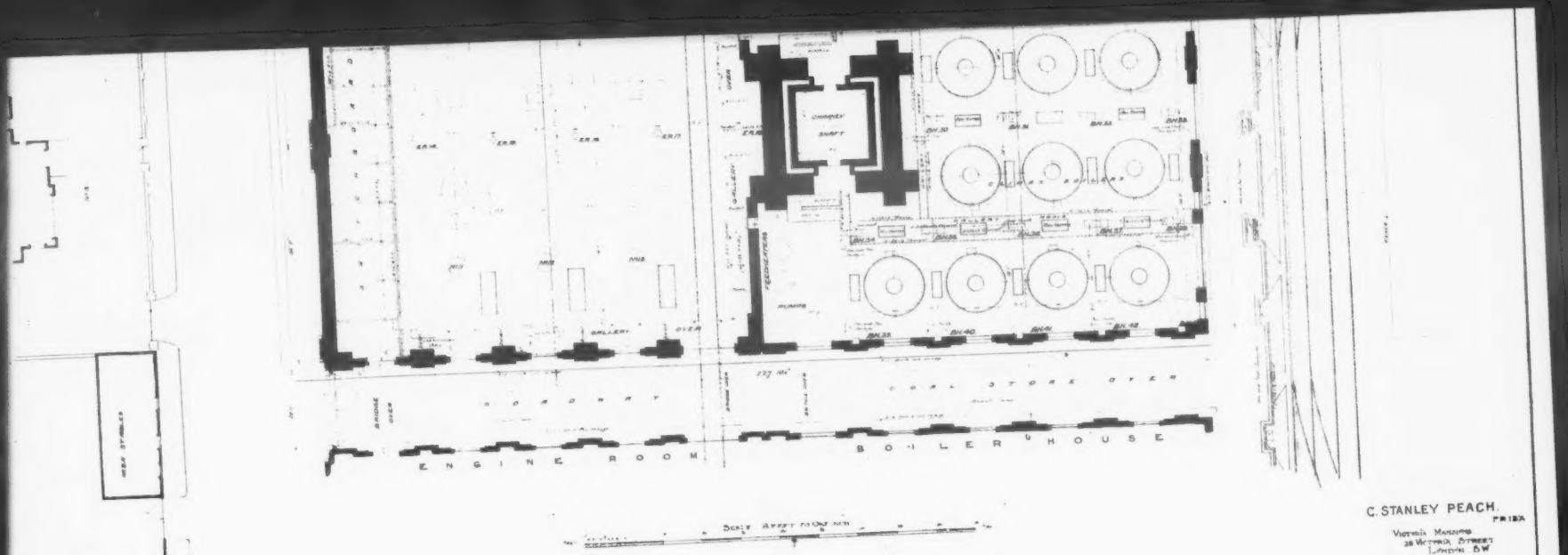
ELEVATION TO LODGE PLACE

C. STANLEY PEACH, F.R.I.B.A.
C. H. REILLY, M.A., A.R.I.B.A.
Architects,
28 VICTORIA ST
S.W.

KENNEDY AND JENKEN Engineers
AND SYDNEY T. DORE Esq. Engineer


17 Victoria Street
London S.W
Carnaby Street
London. S.W
Plan at Engine Room Level
Plan through Window Jambs
Pipe Gallery
Switch Board Gallery
Engine Block
Engine Block
Engine Block
Engine Block
Section A-B
C.F.KELL & SON, LITH 8, FURNIVAL St HOLBORN, E.C.


THE CENTRAL ELECTRIC SUPPLY COMPANY, LIMITED.
CROVE ROAD STATION. MARYLEBONE, N.W.
GROUND FLOOR PLAN.
GREAT CENTRAL RAILWAY COMPANY
NORTH BANK
WATER SOFTENING PLANT
WORKSHOP
ENGINE ROOM
FEED HEATERS AND PUMPS
CHIMNEY SHAFT
OAK TREE ROAD
LODGE ROAD

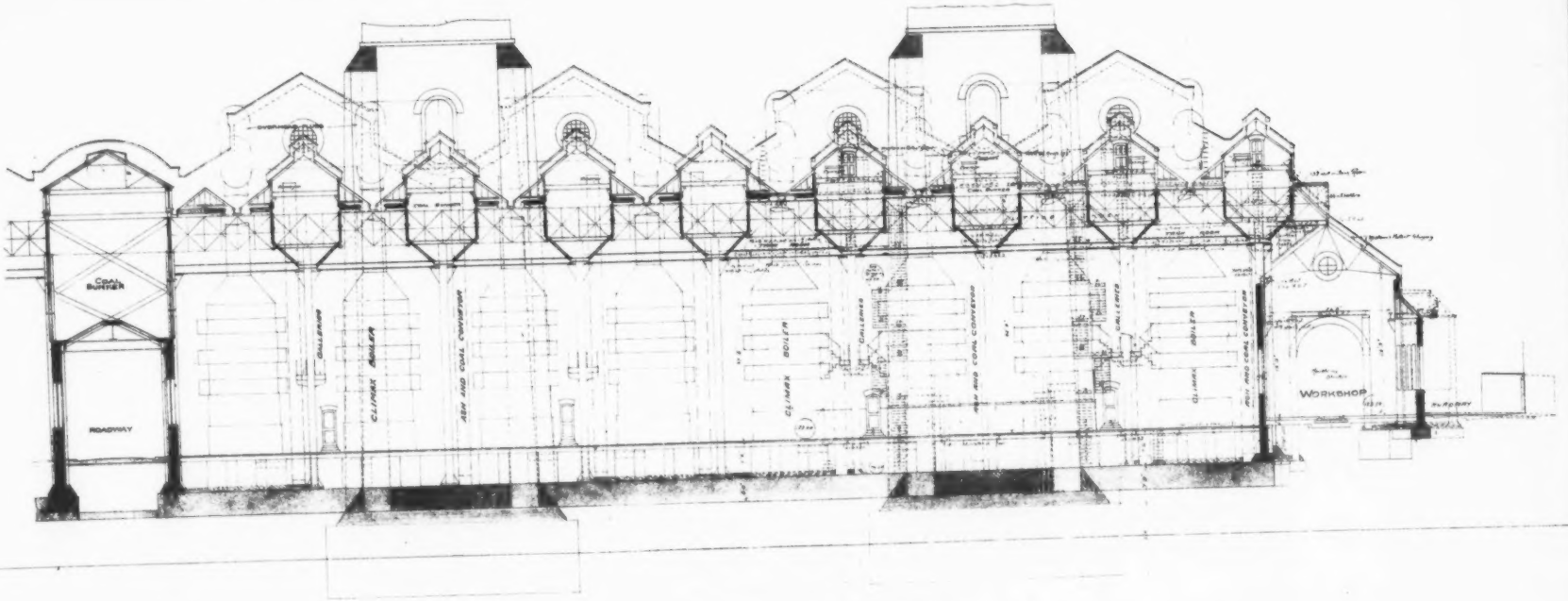


C. STANLEY PEACH.
FRIBA
Victoria Mansions
28 Victoria Street
London SW

Messrs Kennedy and Jenkin
17 Victoria Street
London SW
} Engineers

Sidney T Dobson
Chancery Street
London W

VIRGINIA TECH

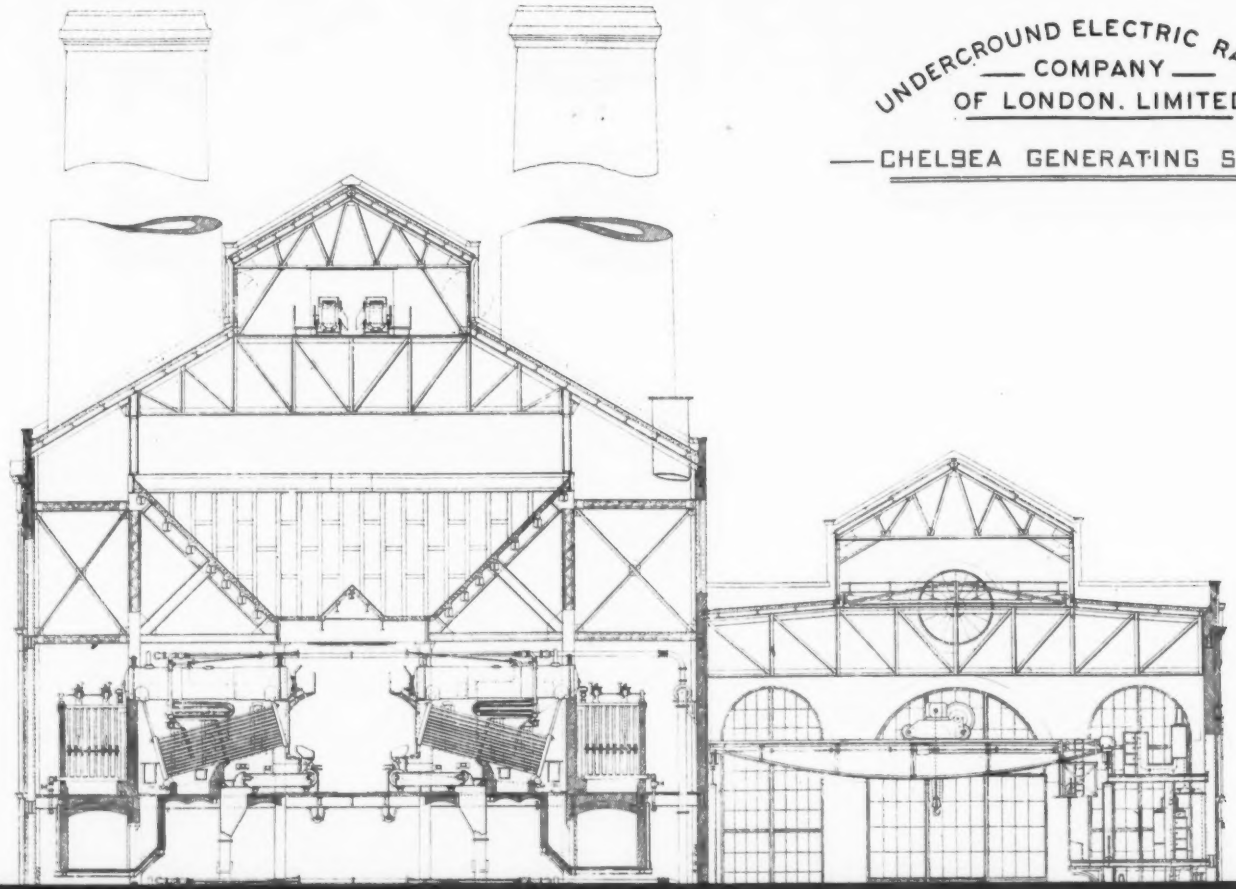


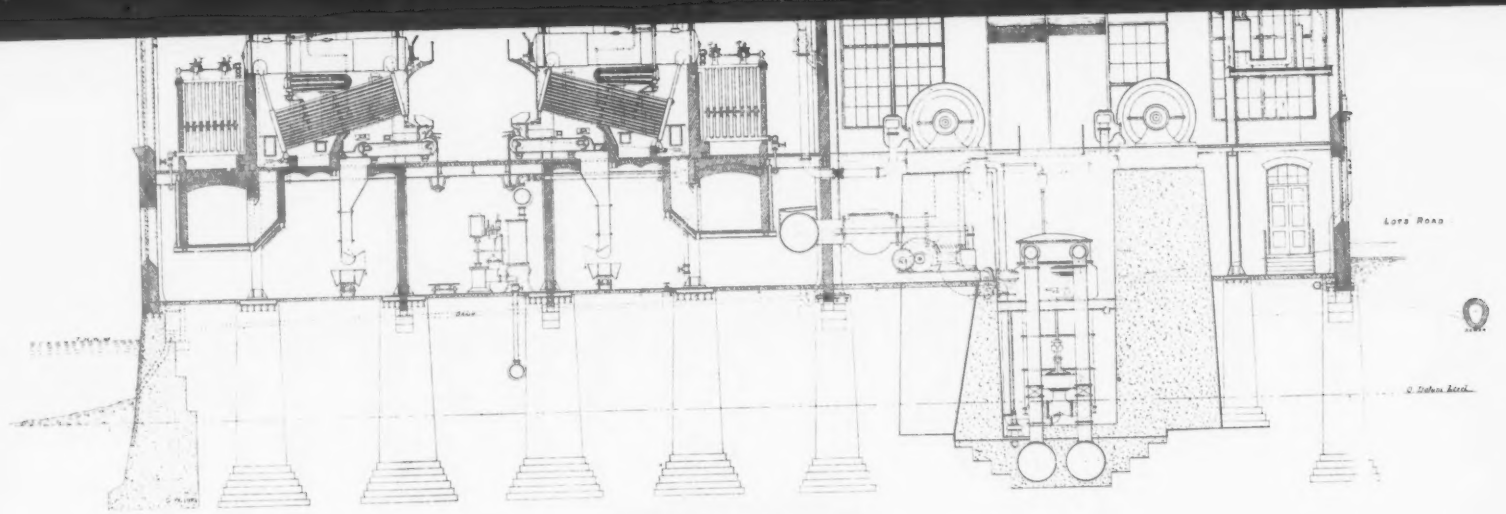
TRANSVERSE SECTION THROUGH BOILER HOUSE

C.F.KELL & SON, LITH 8, FURNIVAL St HOLBORN, E.C.

UNDERGROUND ELECTRIC RAILWAYS
— COMPANY —
OF LONDON. LIMITED.

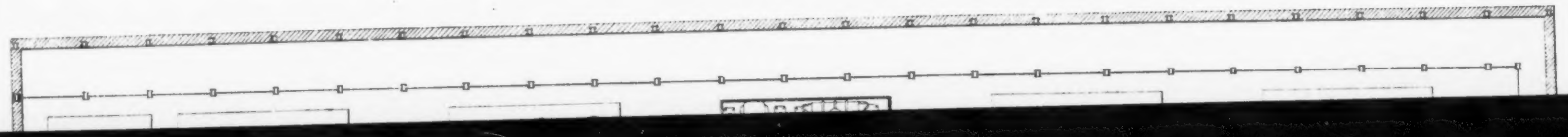
— CHELSEA GENERATING STATION. —

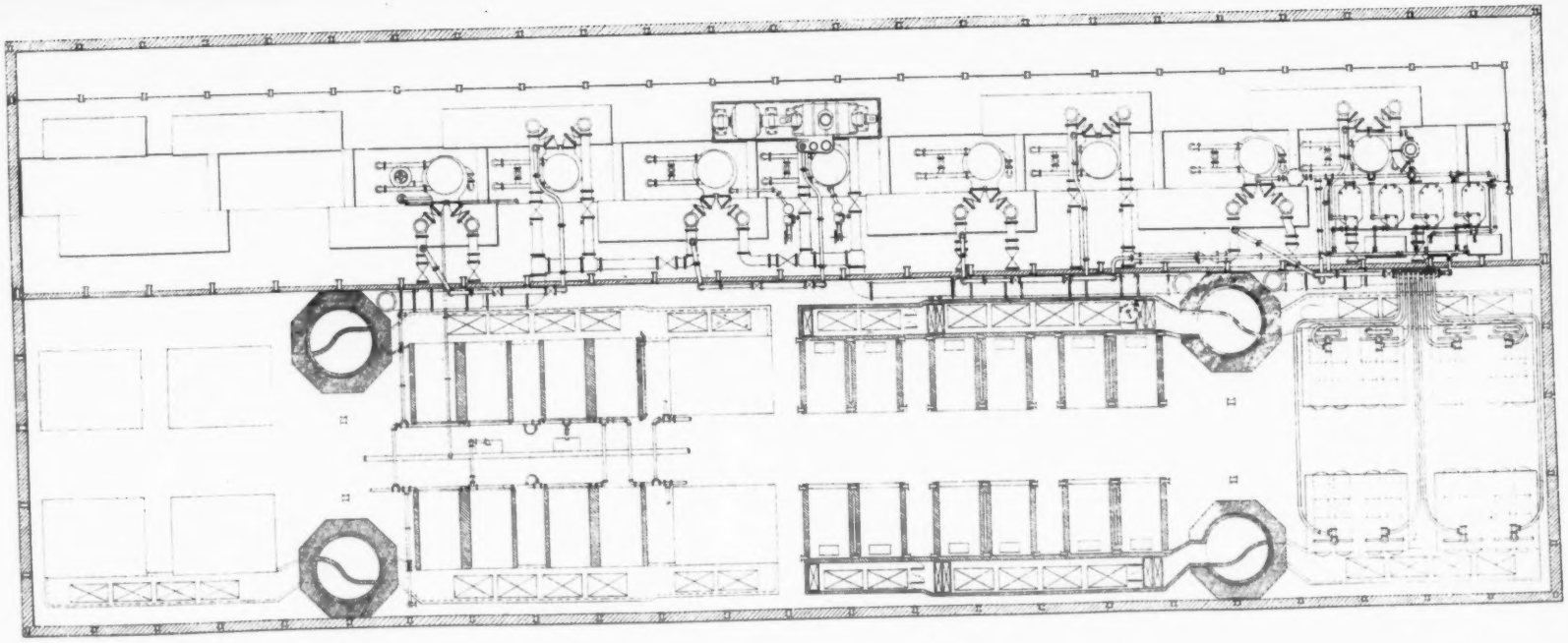




TRANSVERSE SECTION

Scale of Feet

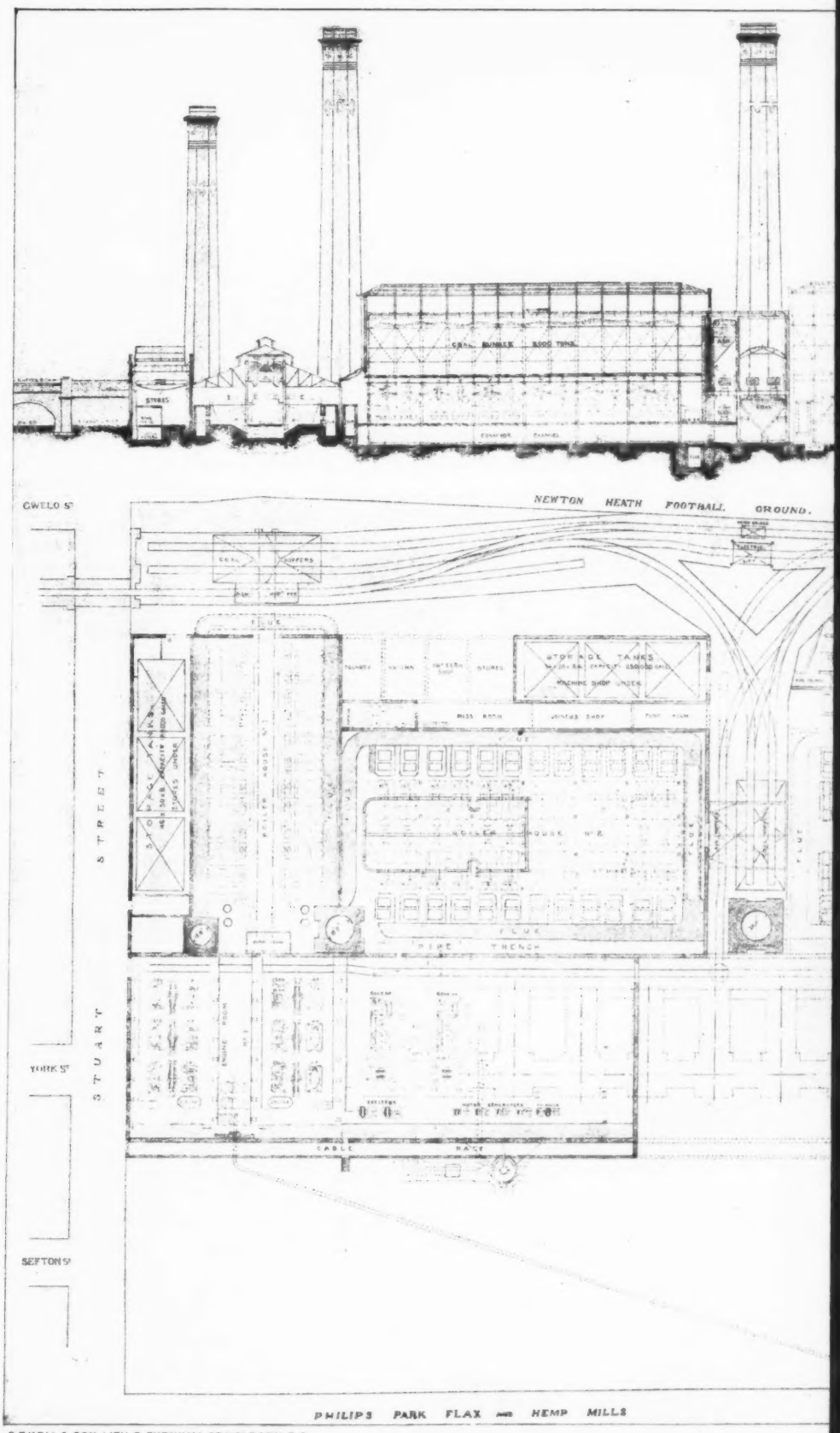




SCALE OF

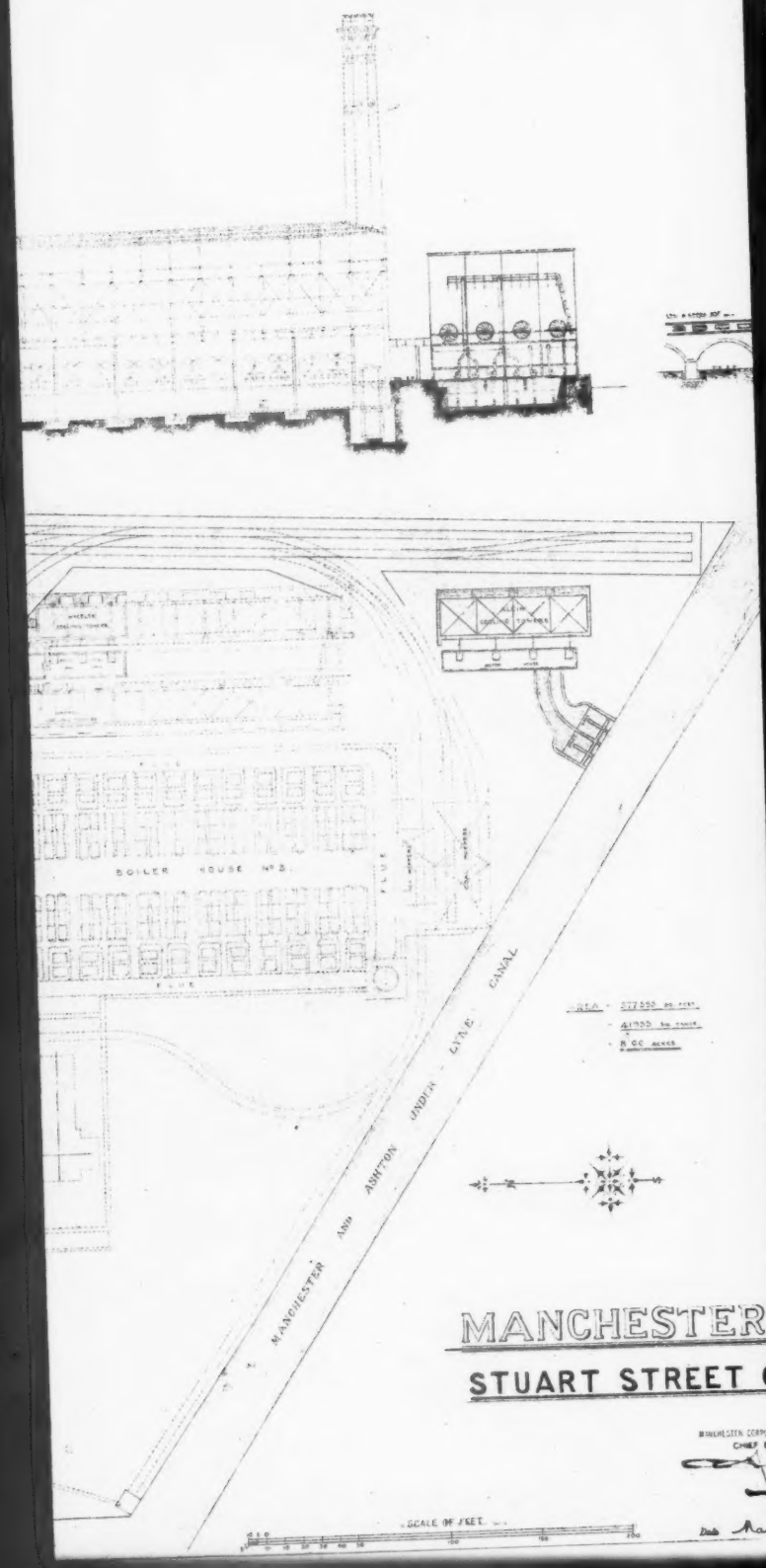
J. R. CHAPMAN,
Engineer.
HAMILTON HOUSE,
VICTORIA EMBANKMENT, E.C.

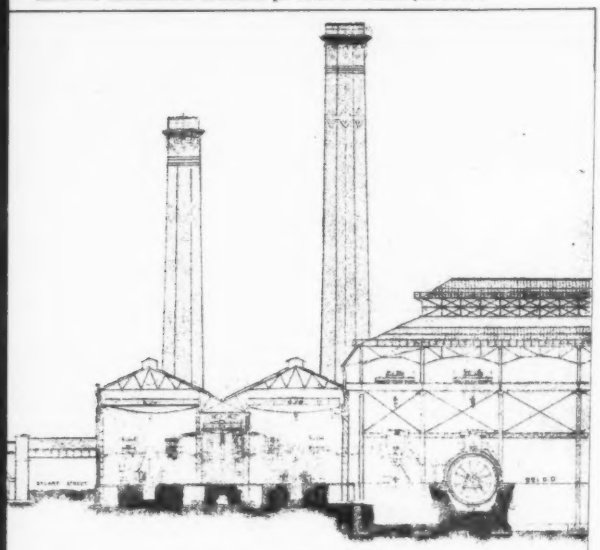
C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

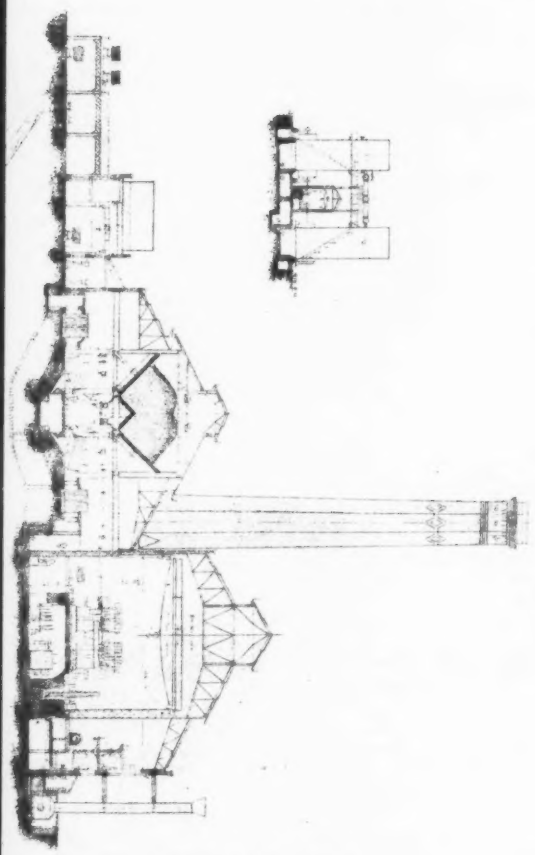


PHILIPS PARK FLAX AND HEMP MILLS

C.F.KELL & SON, LITH 8, FURNIVAL St HOLBORN, E.C.


BOILER HOUSE No 3
FLUE
FLUE
MANCHESTER AND ASHTON UNDER LYNE CANAL
MANCHESTER
STUART STREET C
SCALE OF FEET





CORPORATION.

ENERATING STATION.

...N ELECTRICITY DEPARTMENT.
...NEER'S OFFICE.

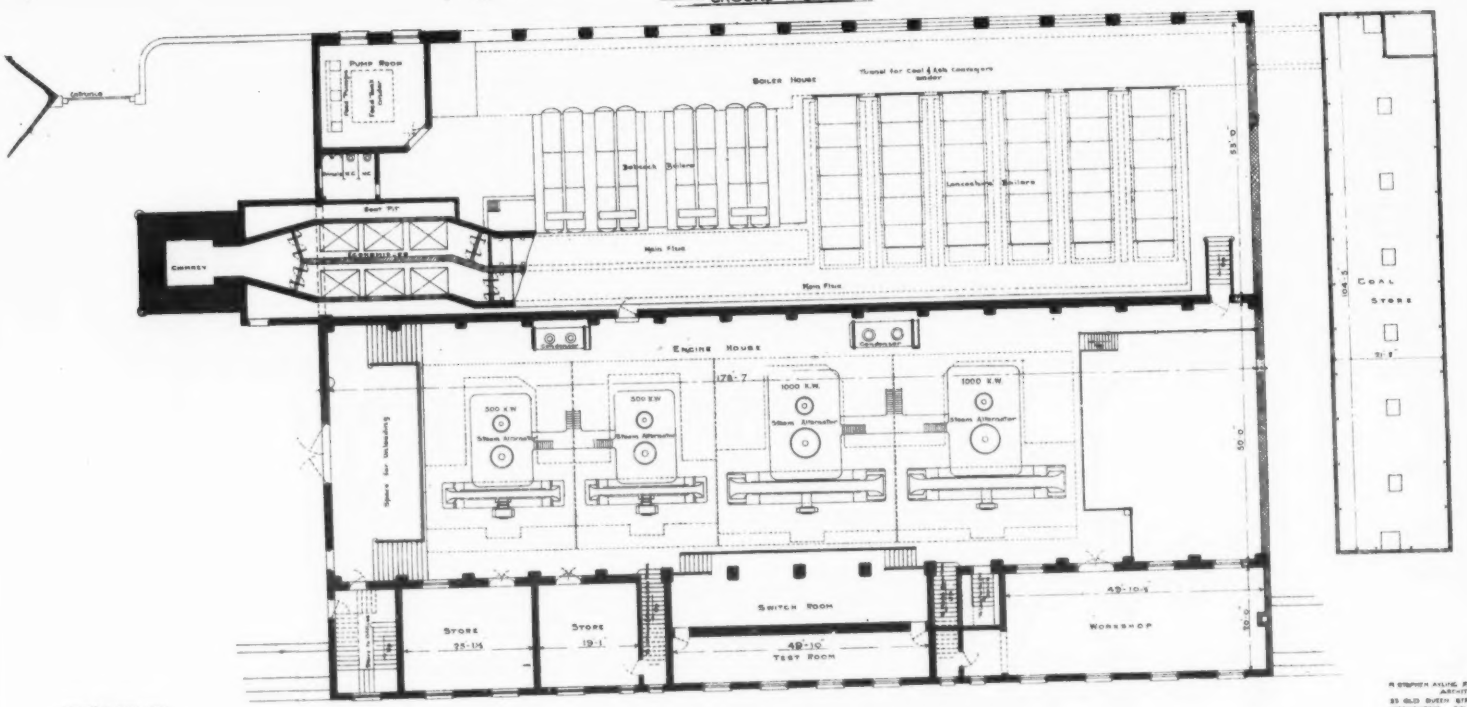
CHIEF ENGINEER

...4th 1903

CITY OF DOUGLAS ARIZONA
AUDITED ELECTRIC WORKS

CITY OF DUBLIN ELECTRICITY WORKS

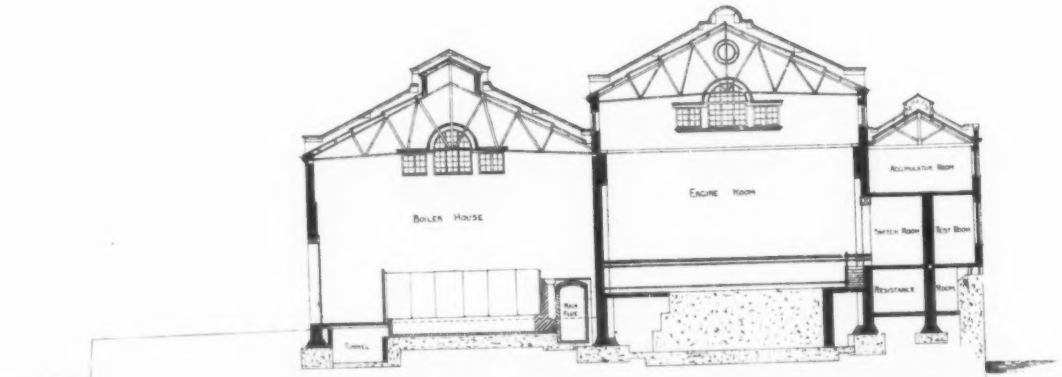
GROUND PLAN



ROBERT HAMMOND RICE
SURVEYOR
64 VICTORIA STREET
WESTMINSTER S.W.

H STEPHEN AYLING A.R.I.B.A.
ARCHITECT
33 OLD QUEEN STREET
WESTMINSTER S.W.

CROSS SECTION

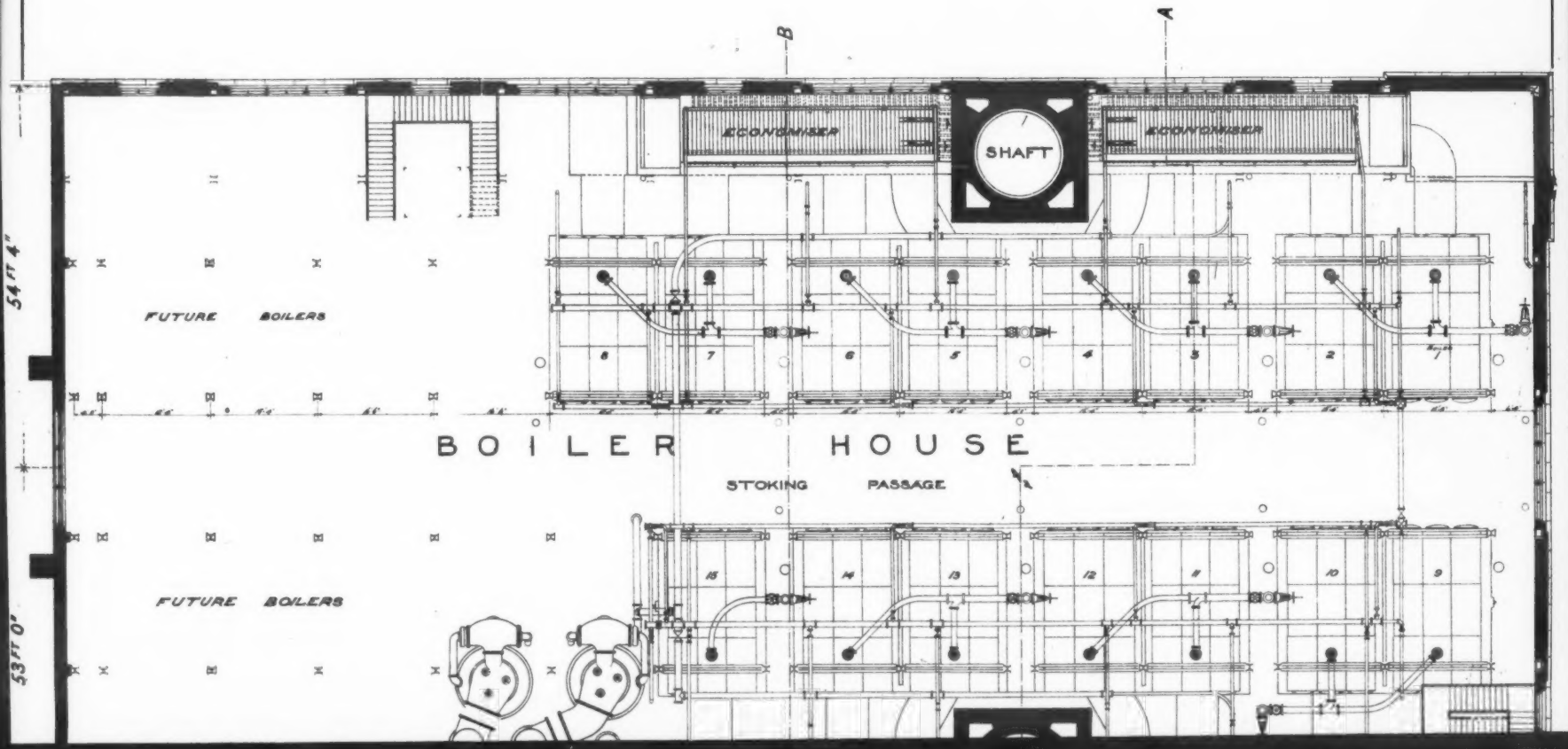


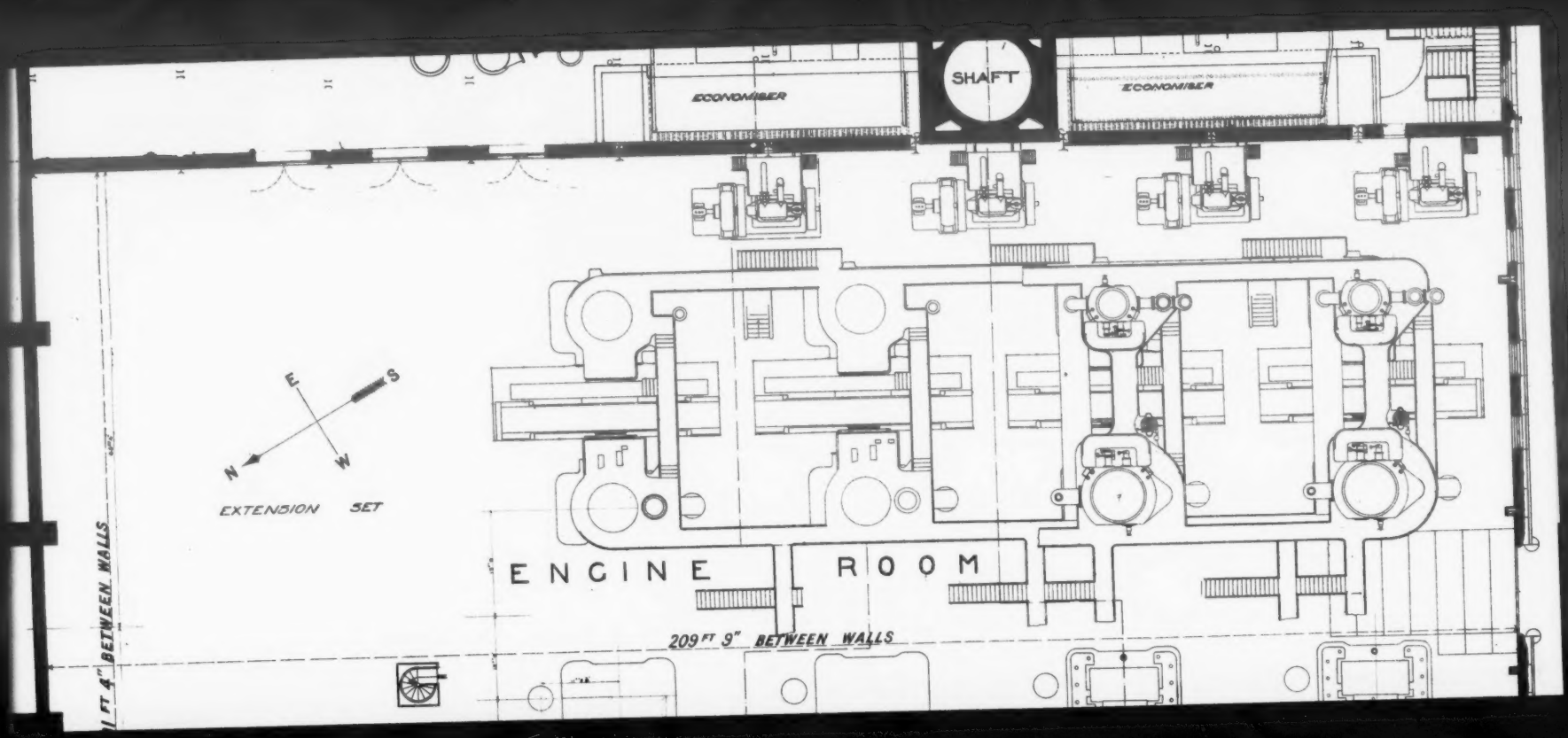
Ordnance Datum

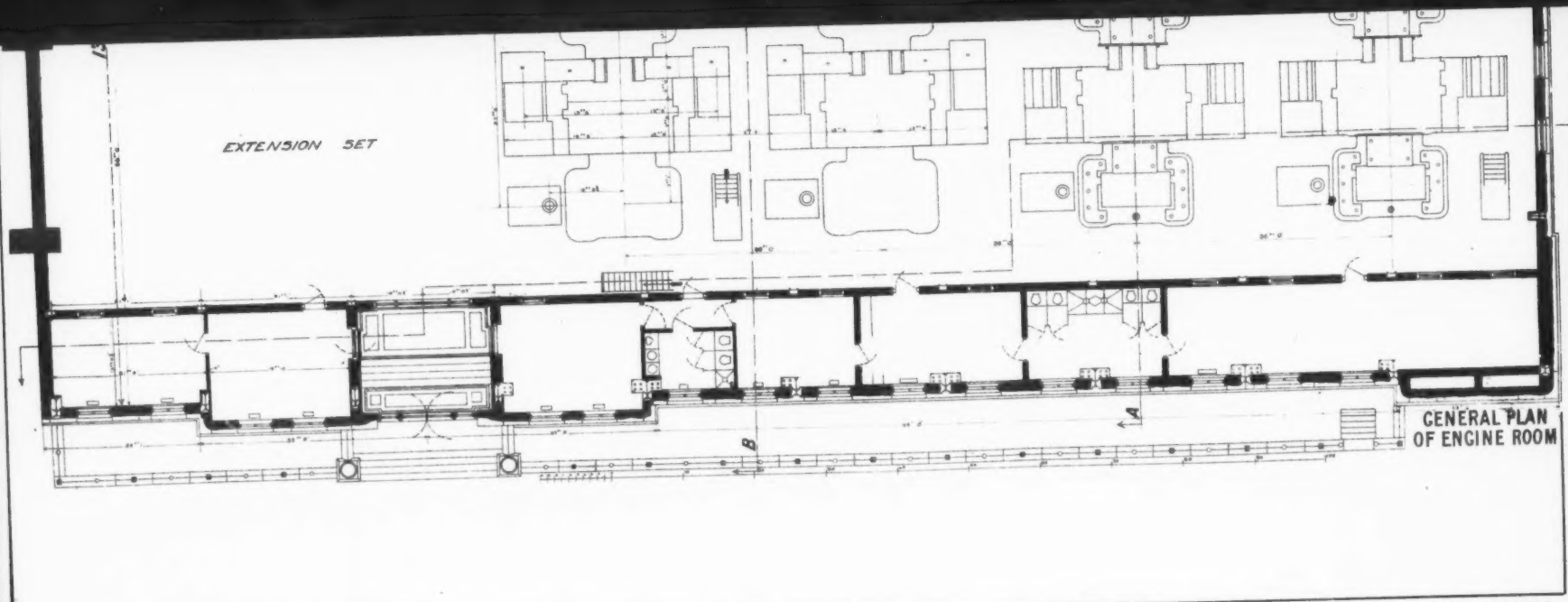
C.F.KELL & SON, LITH. 6 FRONTMAN ST. HOLBORN E.C.

THIRD AVENUE RAILROAD, NEW YORK.

KINGSBRIDGE POWER STATION.

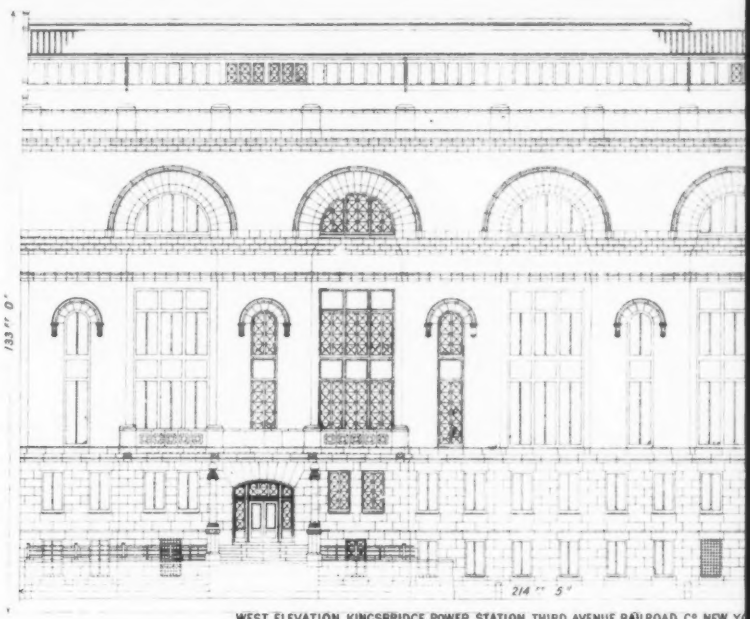



SHAFT
ECONOMISER
ECONOMISER
E
S
N
W
EXTENSION SET
ENGINE ROOM
209 FT 9" BETWEEN WALLS
1 FT 4" BETWEEN WALLS

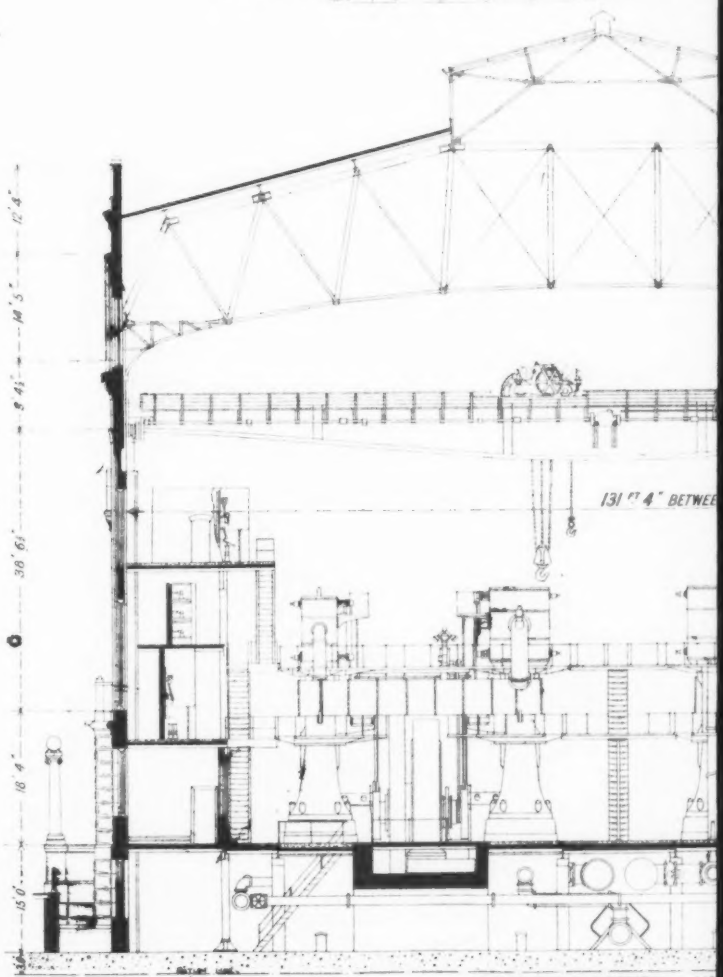


GENERAL PLAN OF ENGINE ROOM

C.F.KELL & SON, LITH 8, FURNIVAL St HOLBORN, E.C.

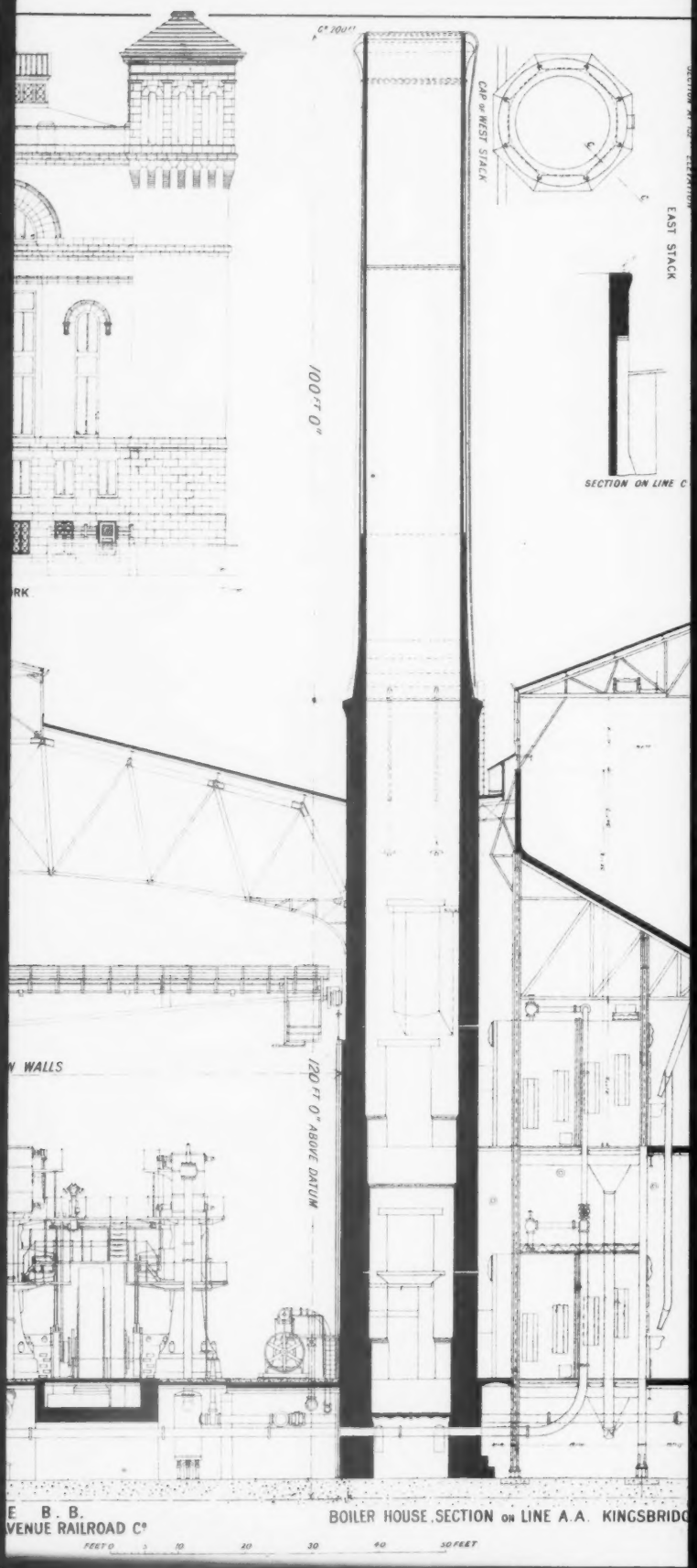


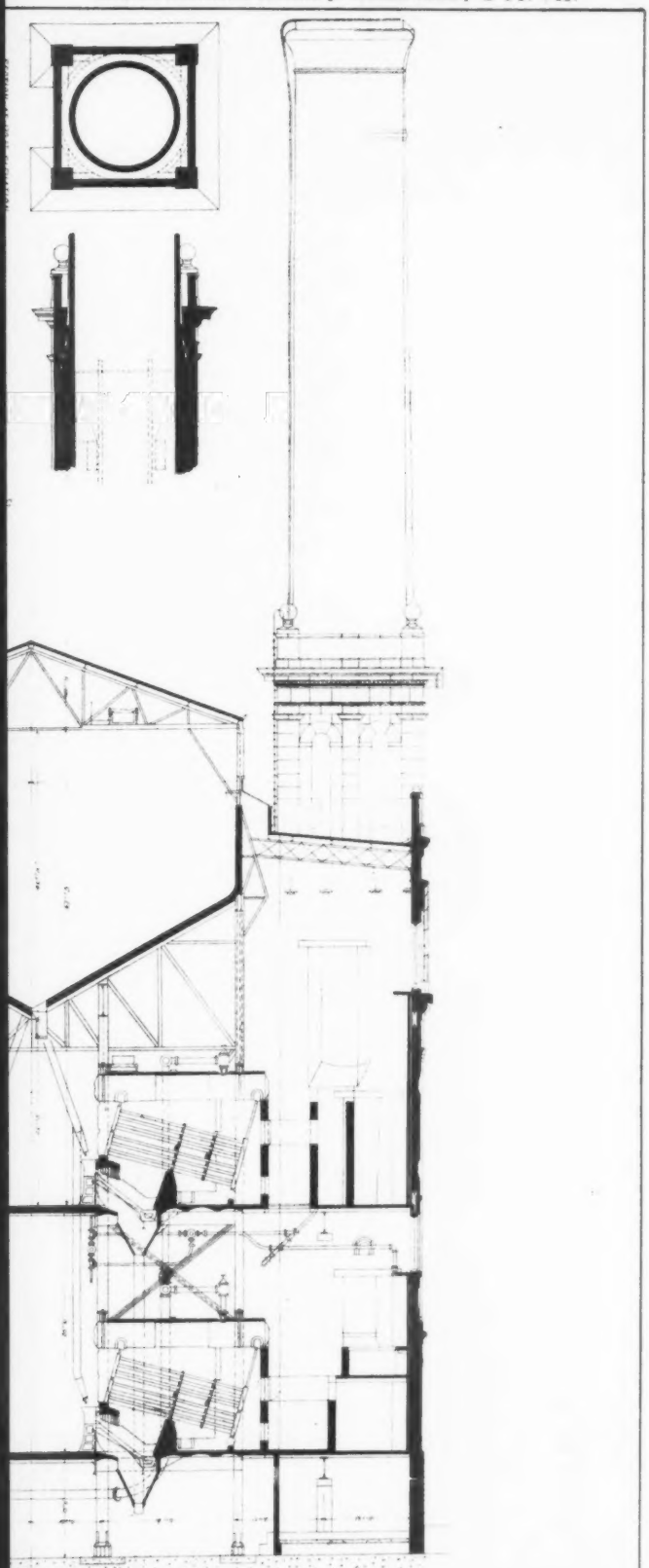
WEST ELEVATION. KINGSBRIDGE POWER STATION. THIRD AVENUE RAILROAD Co. NEW YO



ENGINE ROOM. SECTION ON LIN
KINGSBRIDGE POWER STATION. THIRD A
NEW YORK

THE WESTINGHOUSE, CHURCH, KERR & Co
NEW YORK. Engineers.

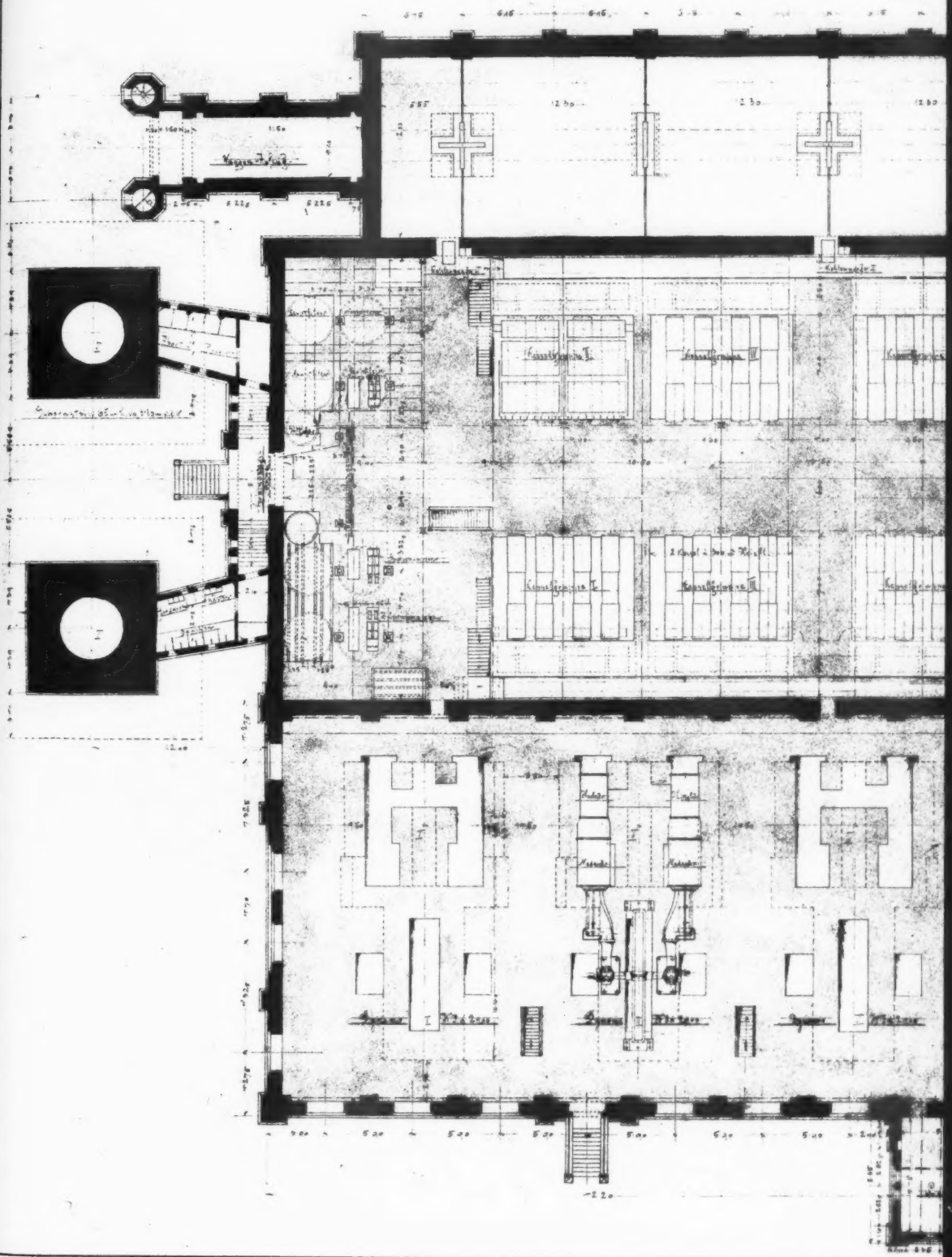

C. 200'
CAP of WEST STACK
EAST STACK
100 FT 0"
SECTION ON LINE C
RK
N WALLS
120 FT 0" ABOVE DATUM
E B. B.
VENUE RAILROAD C°
BOILER HOUSE. SECTION ON LINE A.A. KINGSBRIDG
FEET 0 5 10 20 30 40 50 FEET

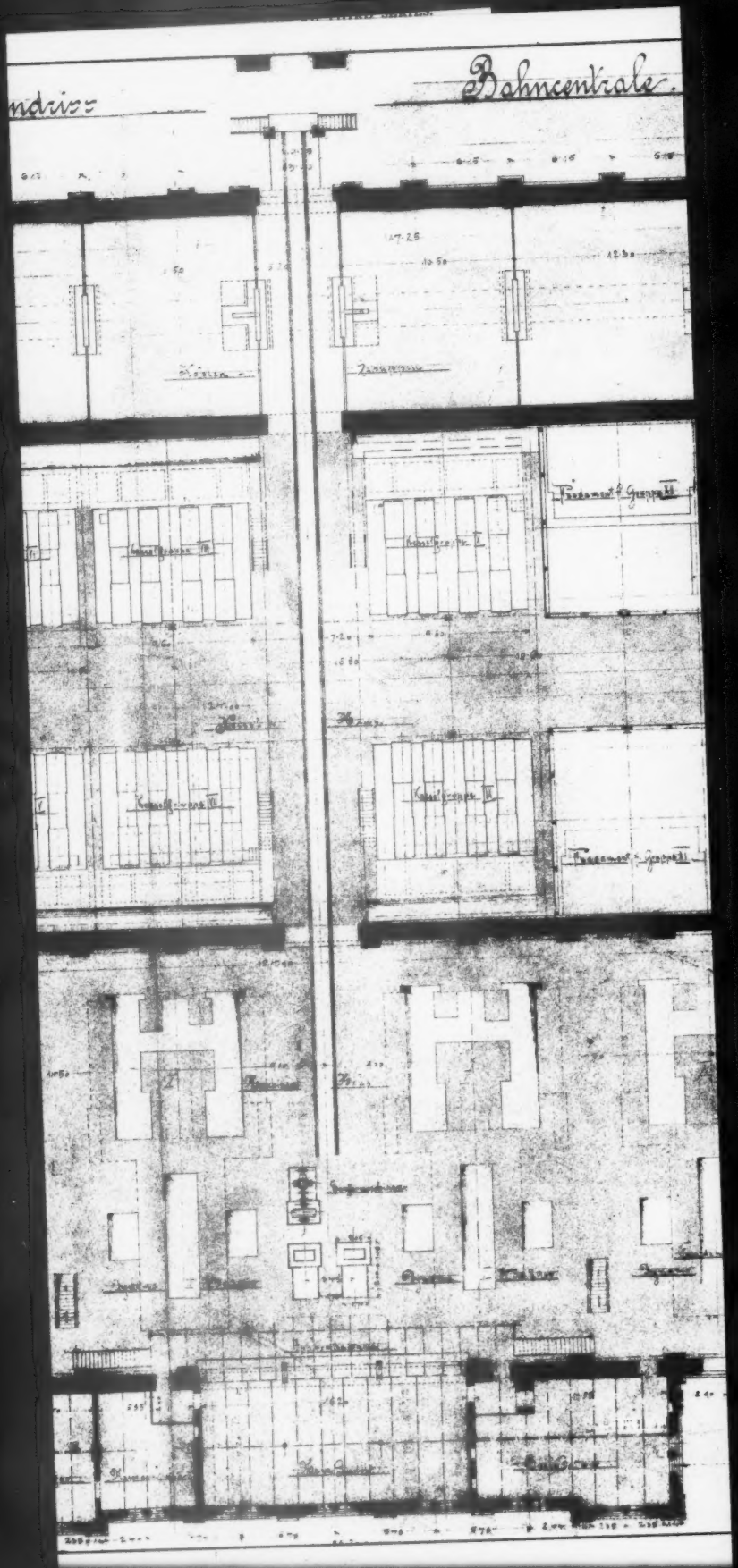


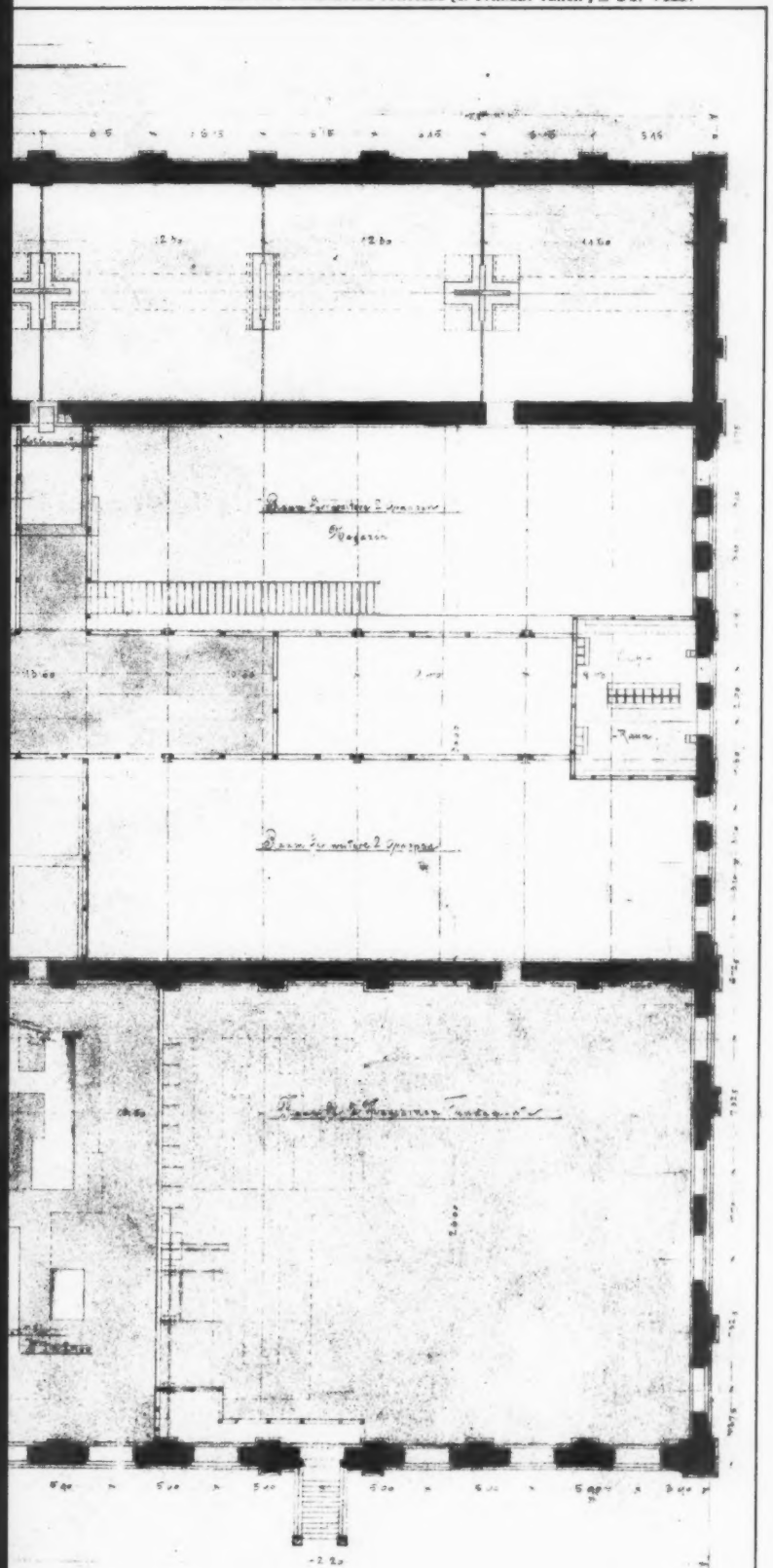
E POWER STATION. THIRD AVENUE RAILROAD Co. NEW YORK.

C.F.KELL & SON, LITH. 8, FURNIVAL ST. HOLBORN E.C.

ELECTRIC POWER STATION OF THE MUNICIPALITY OF VIENNA.




Bahncentrale.



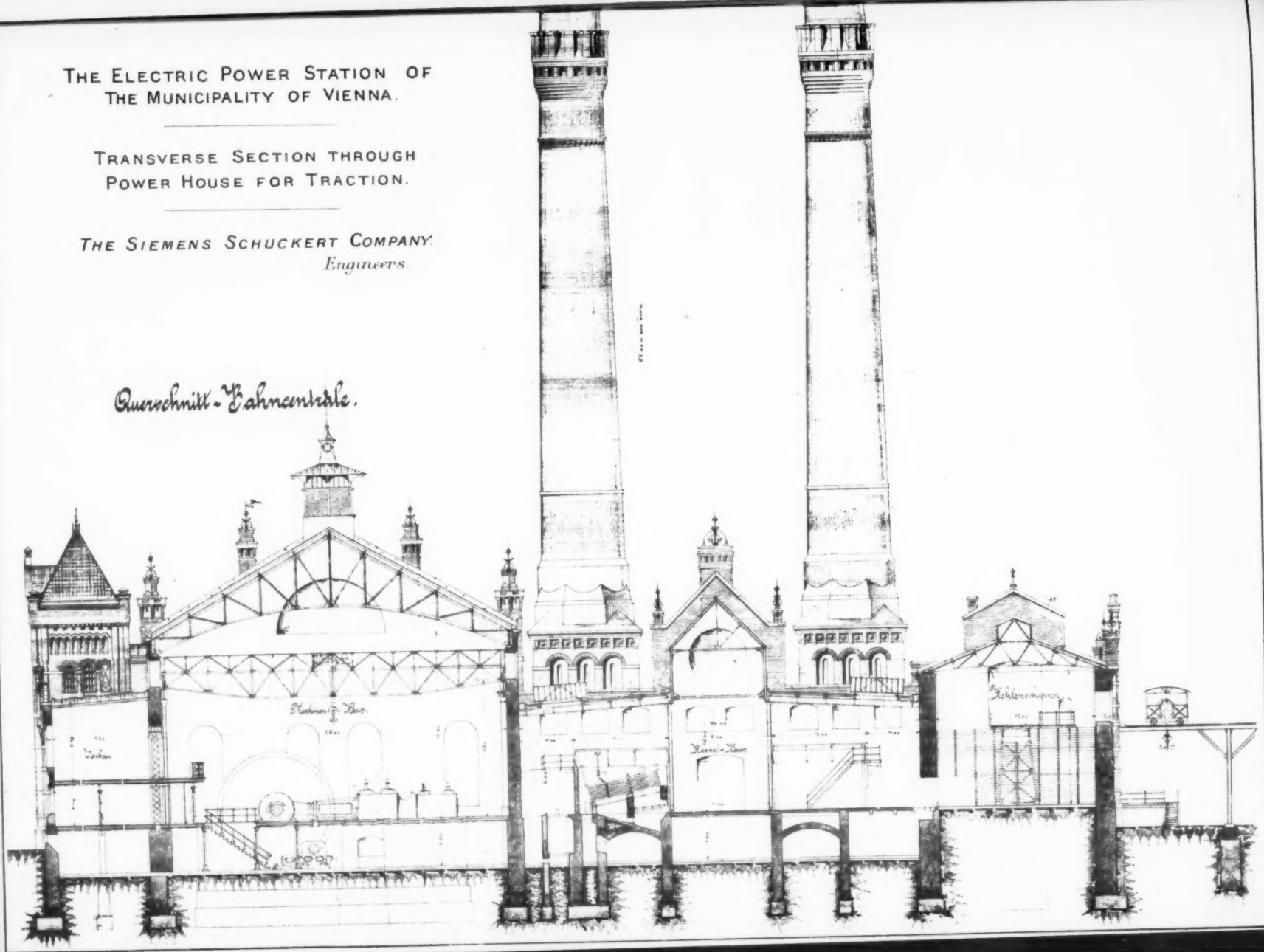
J. F. KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

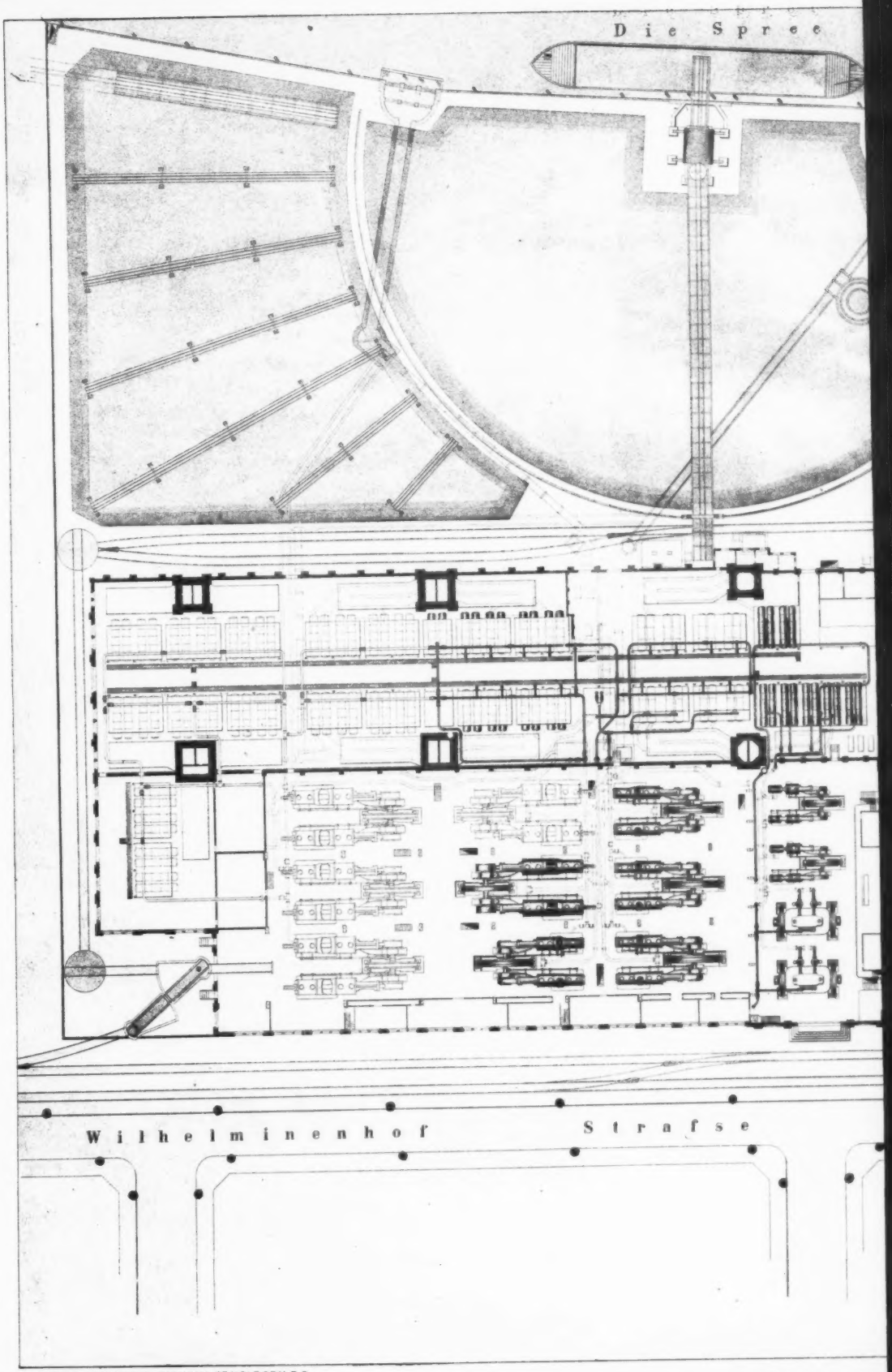
THE ELECTRIC POWER STATION OF
THE MUNICIPALITY OF VIENNA.

TRANSVERSE SECTION THROUGH
POWER HOUSE FOR TRACTION.

THE SIEMENS SCHUCKERT COMPANY.
Engineers.

Querschnitt - Bahncentrale.

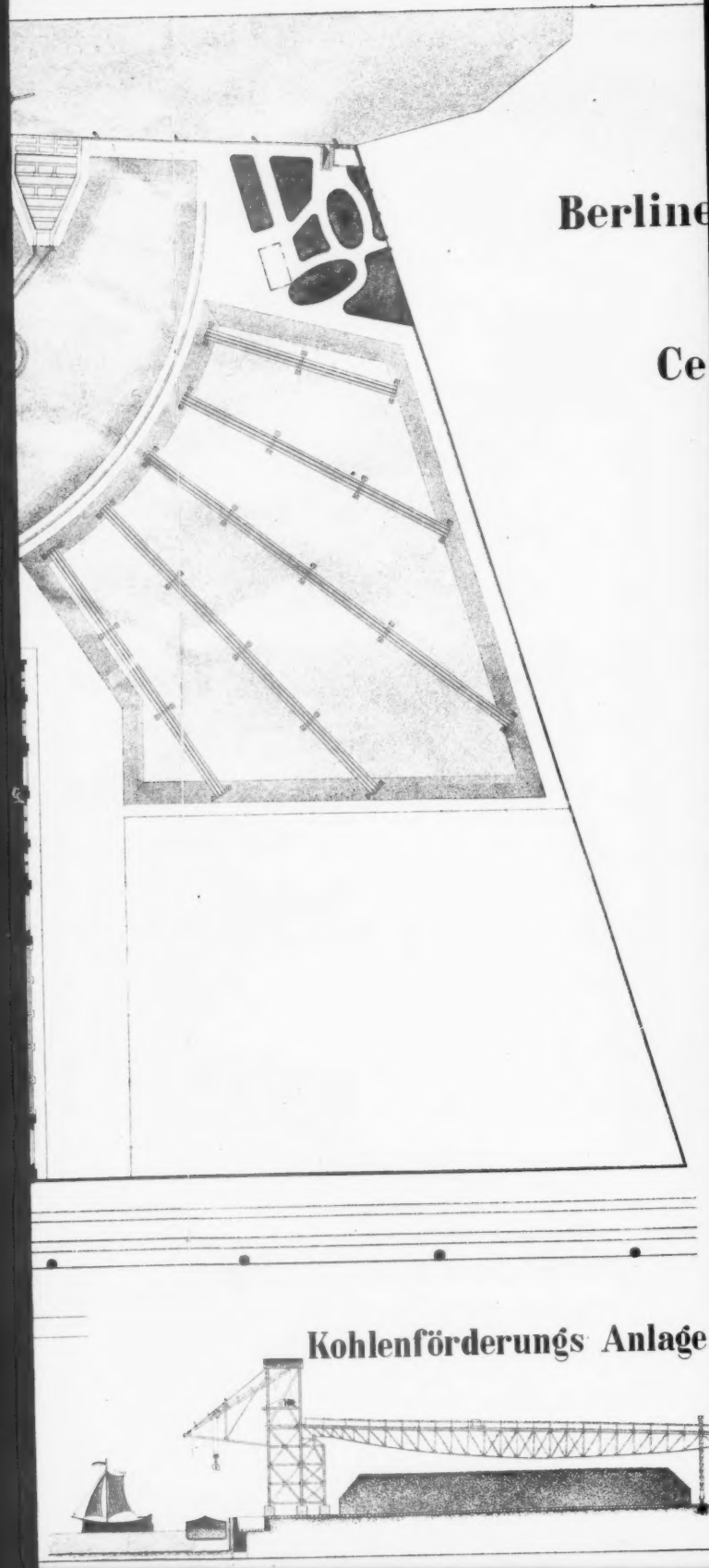




C.F.KELL & SON, LITH. 8, FURNIVAL St HOLBORN, E.C.

Berline

Ce

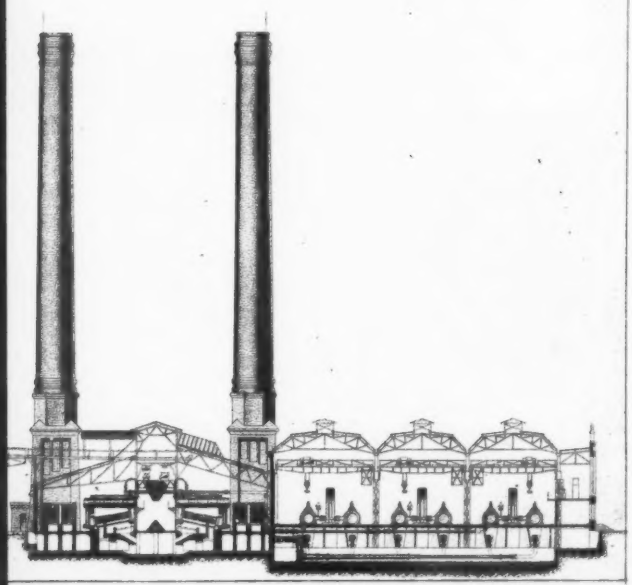


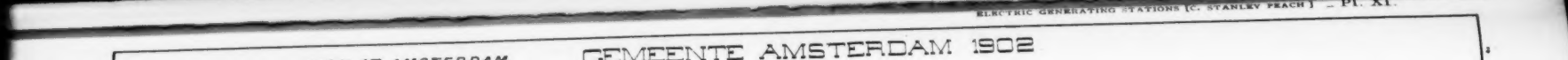
Kohlenförderungs Anlage.

ɛr Elektricitäts Werke

ntrale Oberspree.

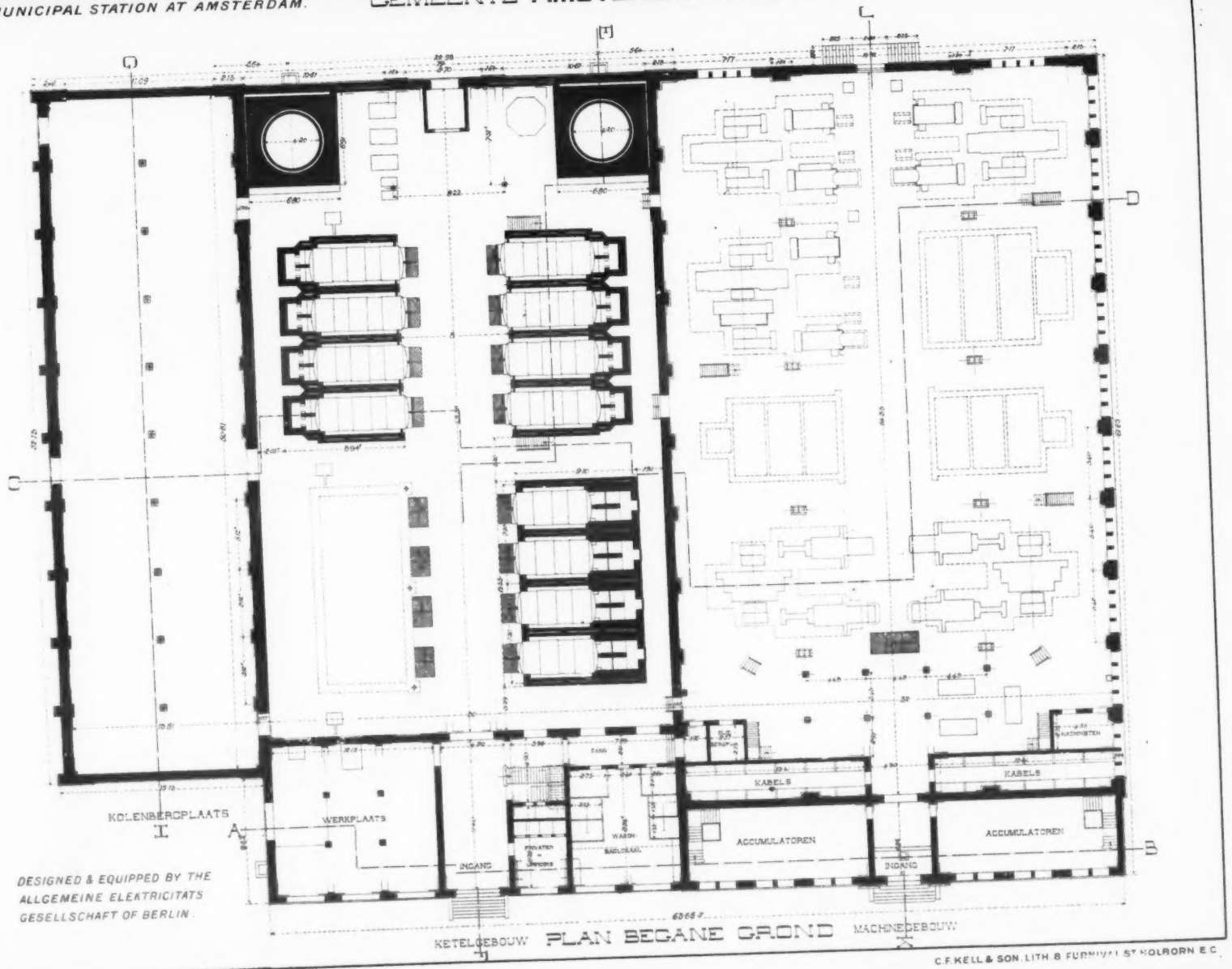
Mafsstab 1:200.




GEMEENTE AMSTERDAM 1902

MUNICIPAL STATION AT AMSTERDAM.

GEMEENTE AMSTERDAM 1902



DESIGNED & EQUIPPED BY THE ALLGEMEINE ELEKTRICITATS GESELLSCHAFT OF BERLIN.

KETELGEBOUW **PLAN BEGANE GROND** MACHINEGEBOUW

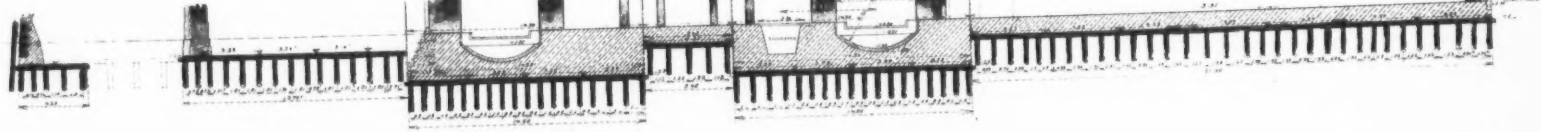
C.F.KELL & SON, LITH. 8 FURNIVAL ST HOLBORN E.C.

Bestek N° 74/1901
AMSTERDAM.
Gemeente Electriciteitswerken.

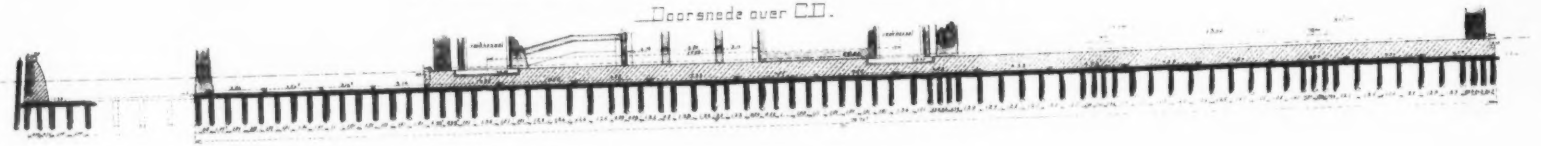
Bestektekening
Blad 3

Doorsneden Paal- en Betonfundeering.

Doorsnede over A.B.

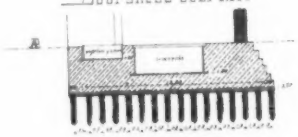


Doorsnede over C.D.



Doorsnede over E.F

Doorsnede over M.N



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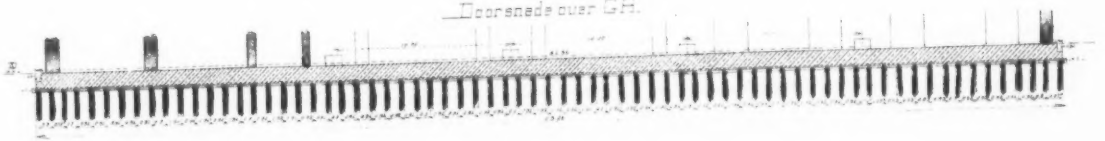

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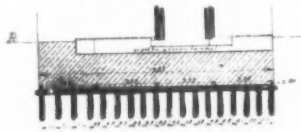
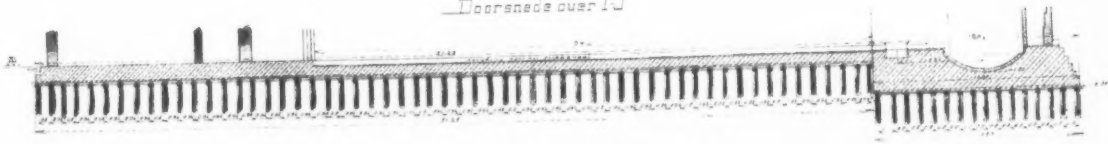
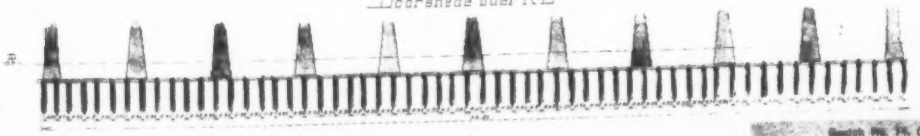


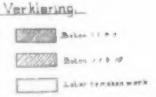
Doorsnede over I.J



Doorsnede over K.L



Verklaring.



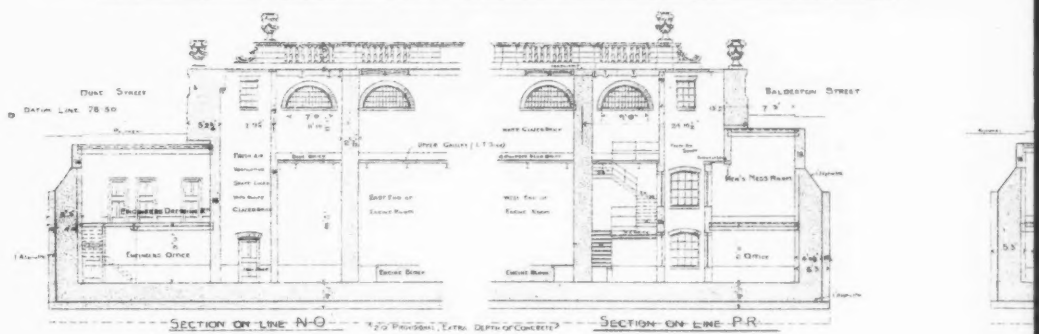
THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT
Engineers.

Schaal 1:100.

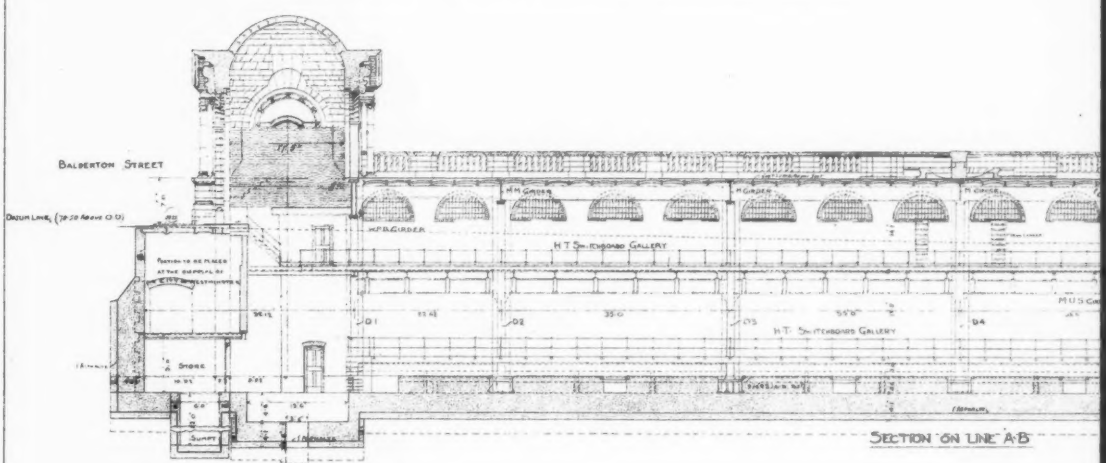
C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

THE W.E.S. CORP LIMTD ~ DUKE STREET.

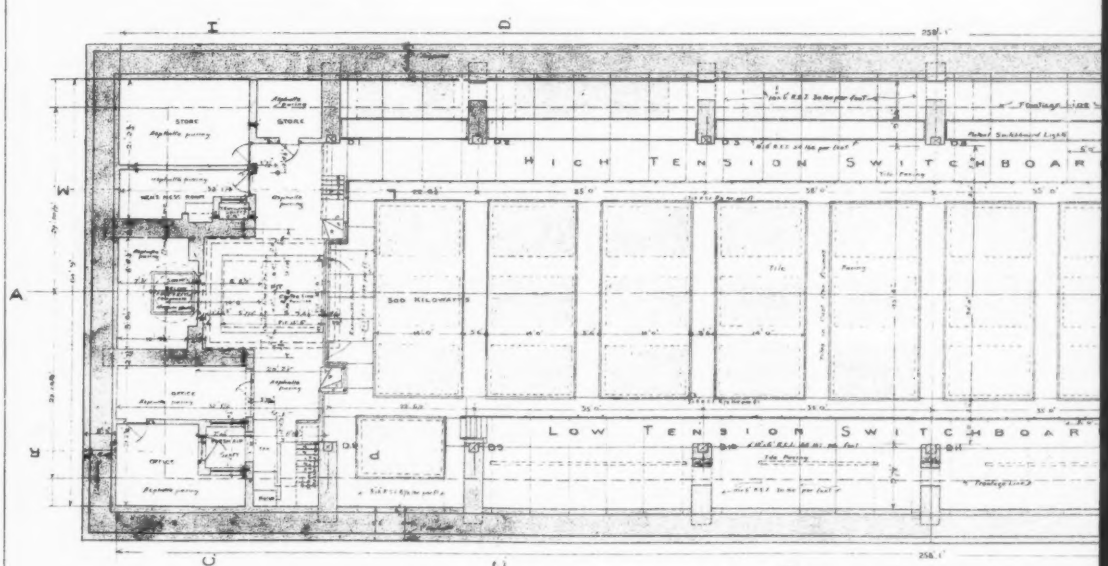
MOTOR GENERATOR STATION & ITALIAN GARDEN



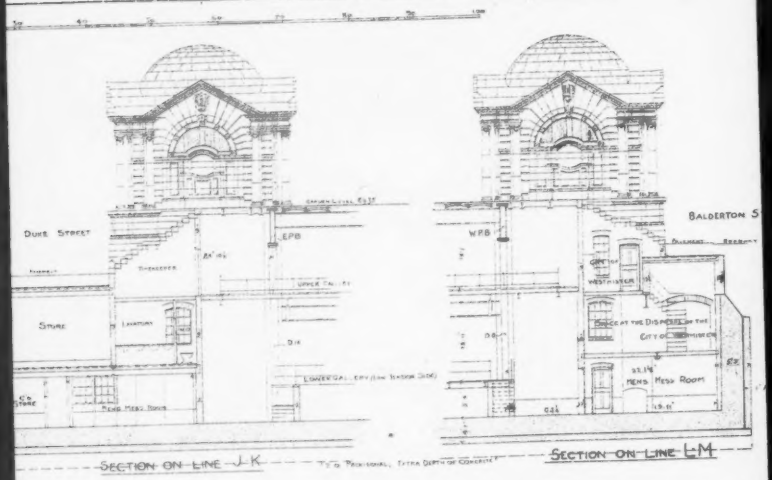
SECTION ON LINE N-O — *2'0 PROVISIONAL EXTRA DEPTH OF CONCRETE? — SECTION ON LINE P.R.

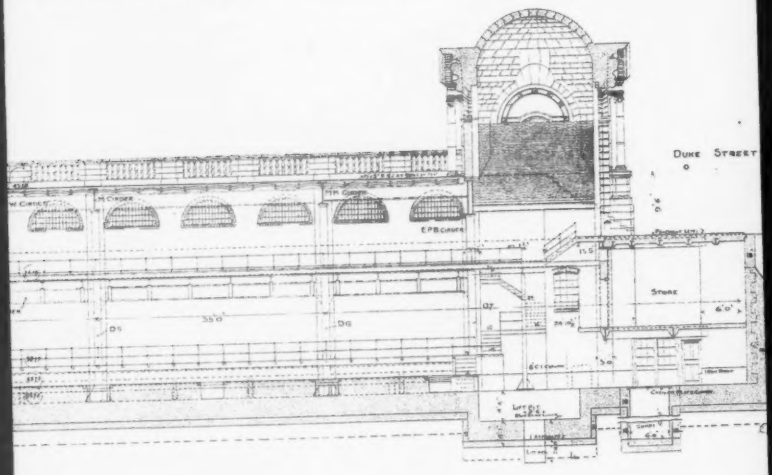


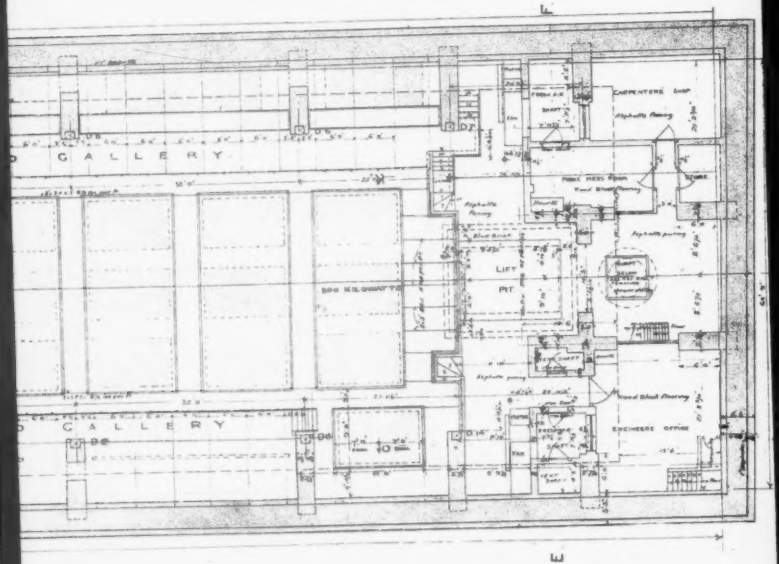
SECTION ON LINE A-B



PLAN AT BASEMENT LEVEL

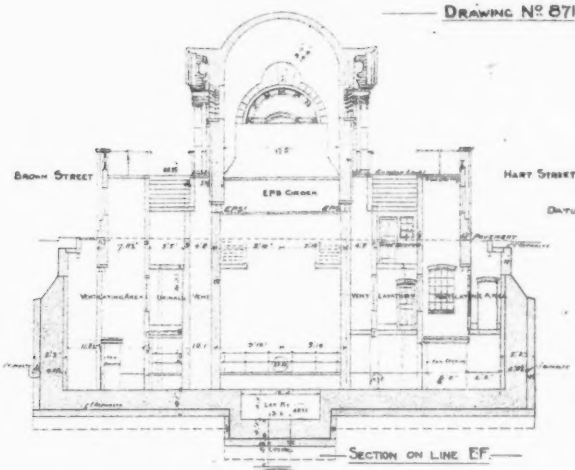

DUKE STREET
BALDERTON S
EPB
WPB
STORE
MENS MESS ROOM
SECTION ON LINE J K
SECTION ON LINE L M

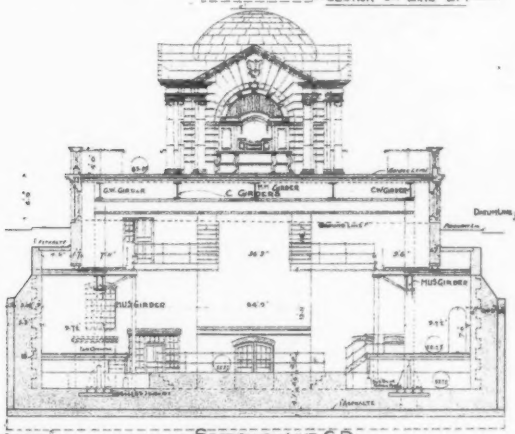

DUKE STREET
STORE

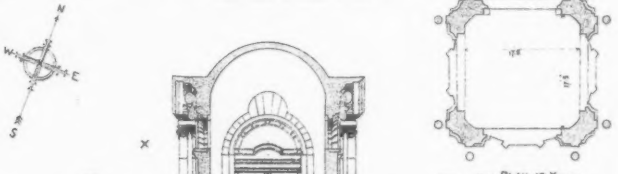

GALLERY
GALLERY
CARPENTERS SHOP
LIFT
PIT
ENGINEERS OFFICE

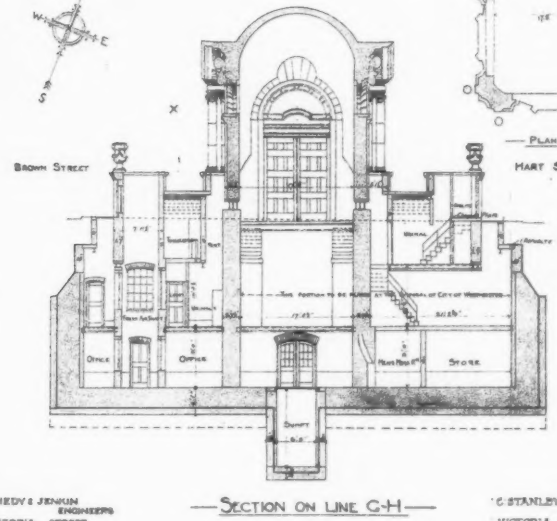
Vanilla

DRAWING Nº 8714







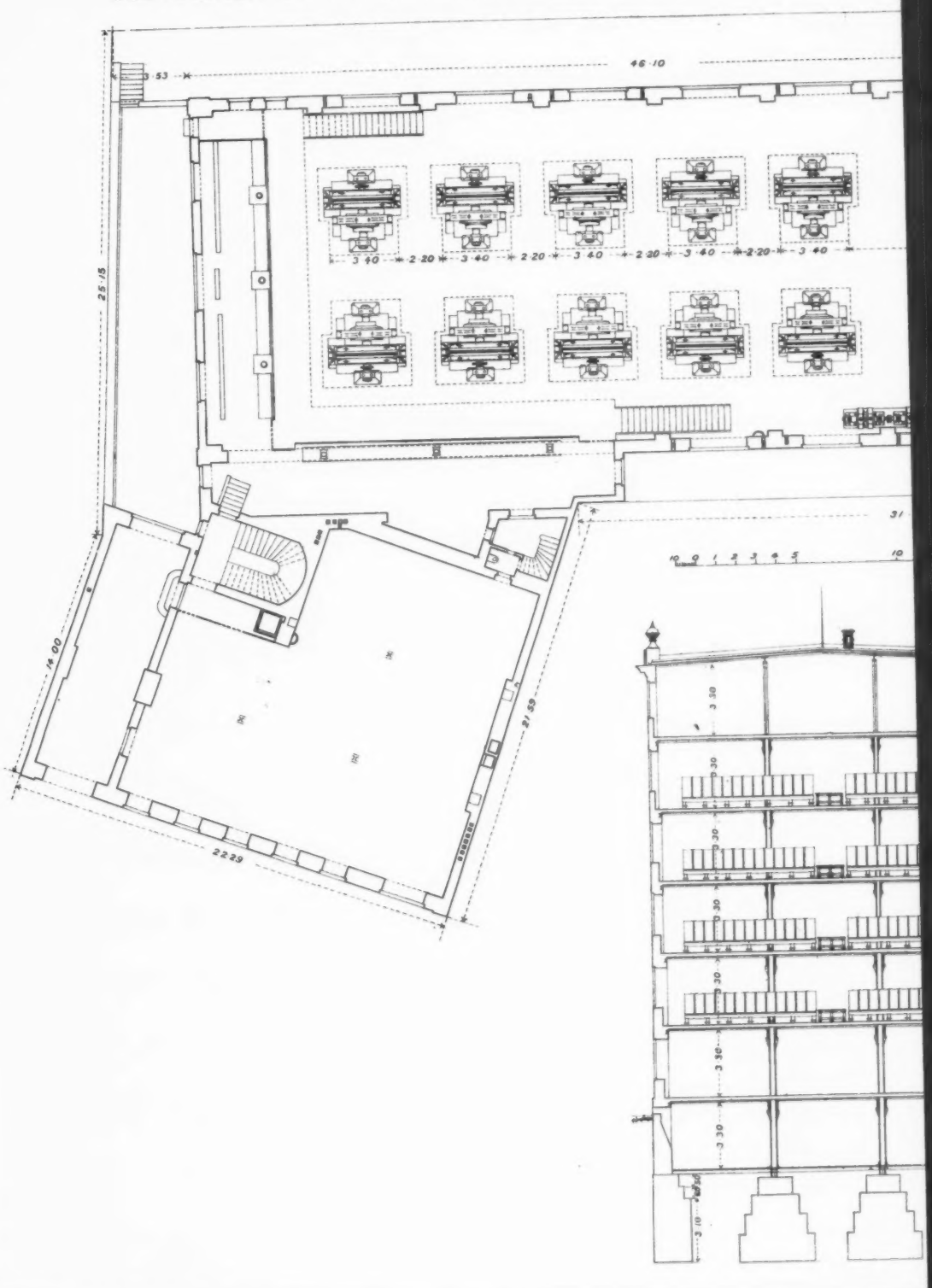


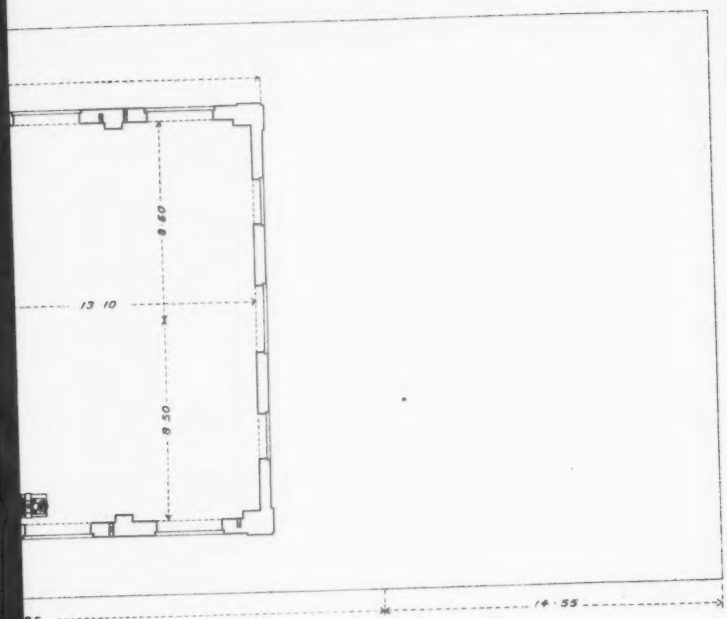
KENNEDY & JENKIN
ENGINEERS
17 VICTORIA STREET
LONDON S.W.

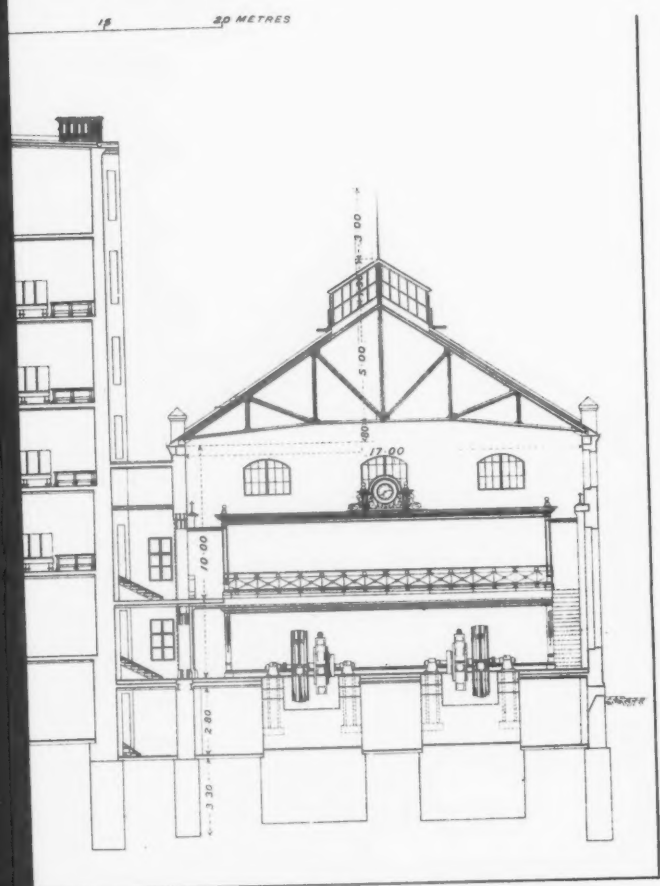
C. STANLEY PEACH, ESQ.
VICTORIA MANSIONS
VICTORIA STREET
LONDON S.W.

C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

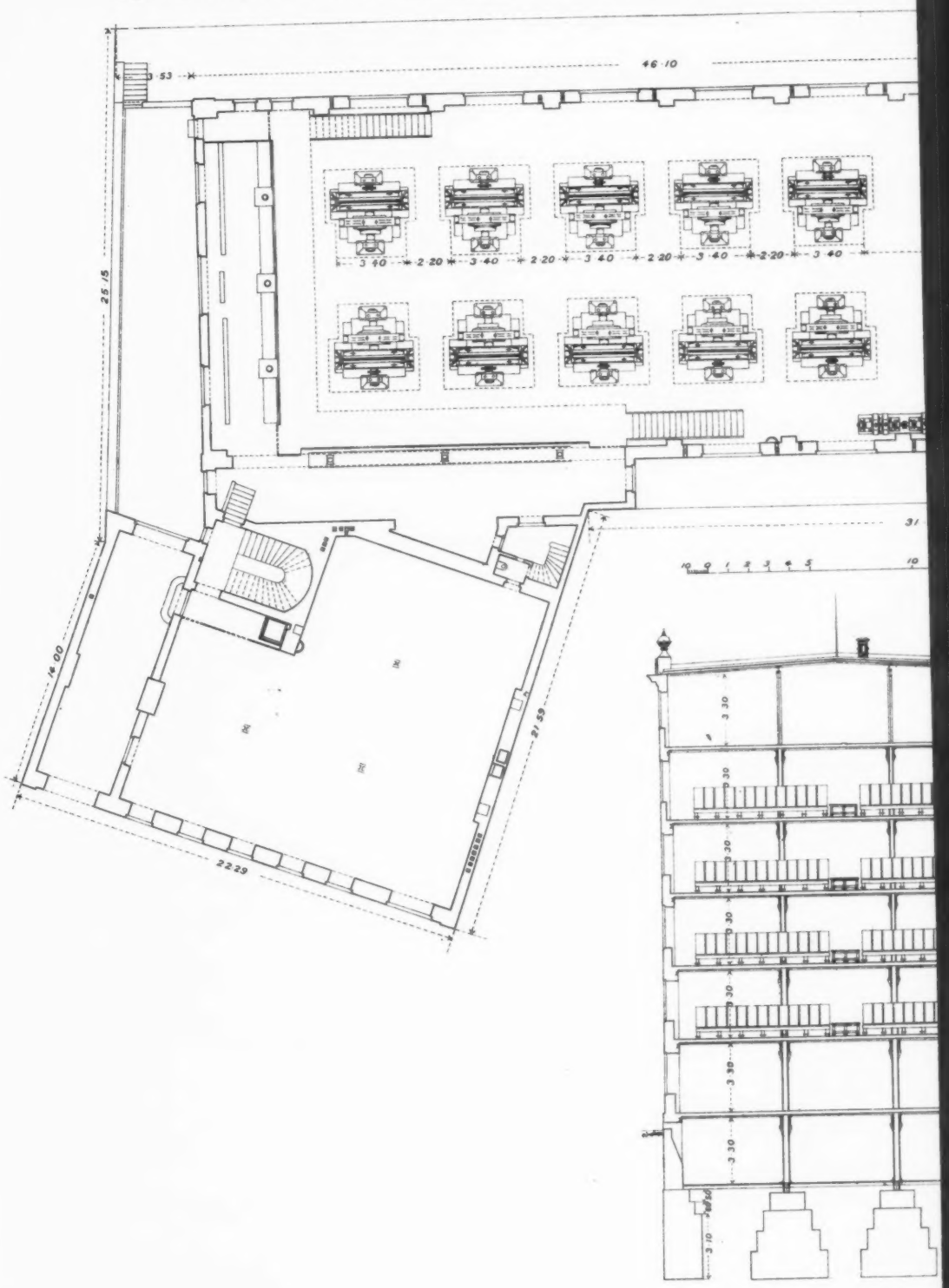
SUB-STATION OF THE MUNICIPALITY OF VIENNA

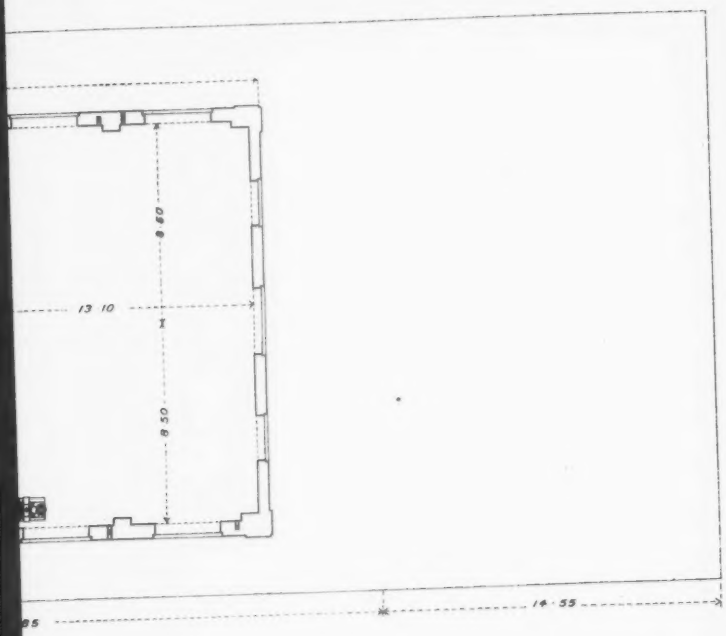


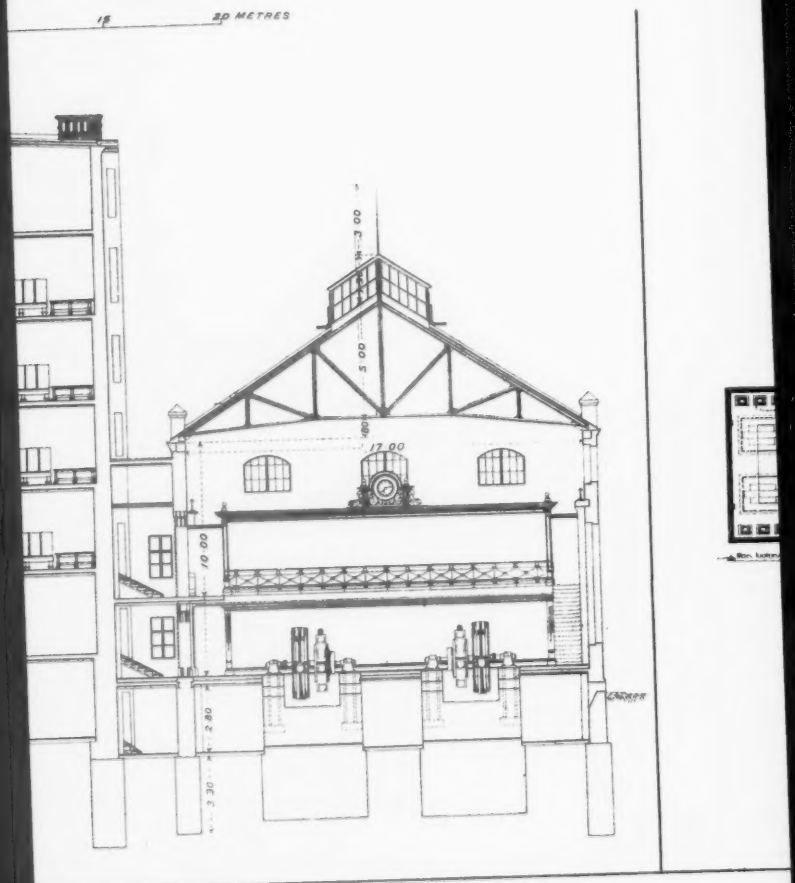

8 60
13 10
8 50
14 55


20 METRES
17 00
10 00
2 80
3 30

Sub-Station of the Municipality of Vienna.

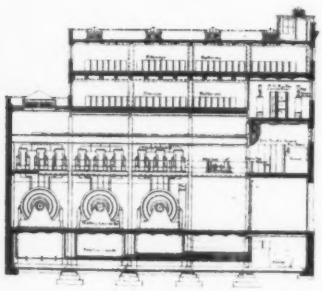



8 60
13 10
8 50
14 · 55

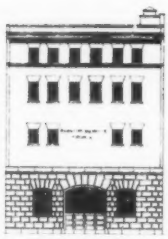

20 METRES
3 00
5 00
17 00
10 00
2 80
3 30

MANHATTAN RAILWAY COMPANY, NEW YORK.

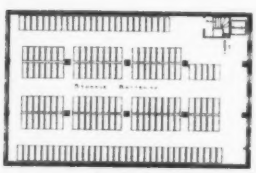
SUB-STATION Nº 6.



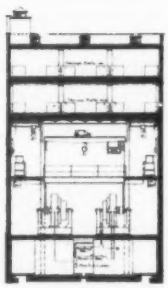
Longitudinal Section



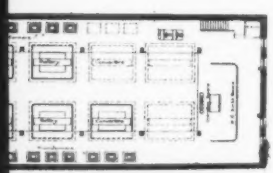
Front Elevation



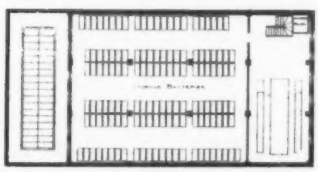
Plan of Upper Battery Floor



Cross Section

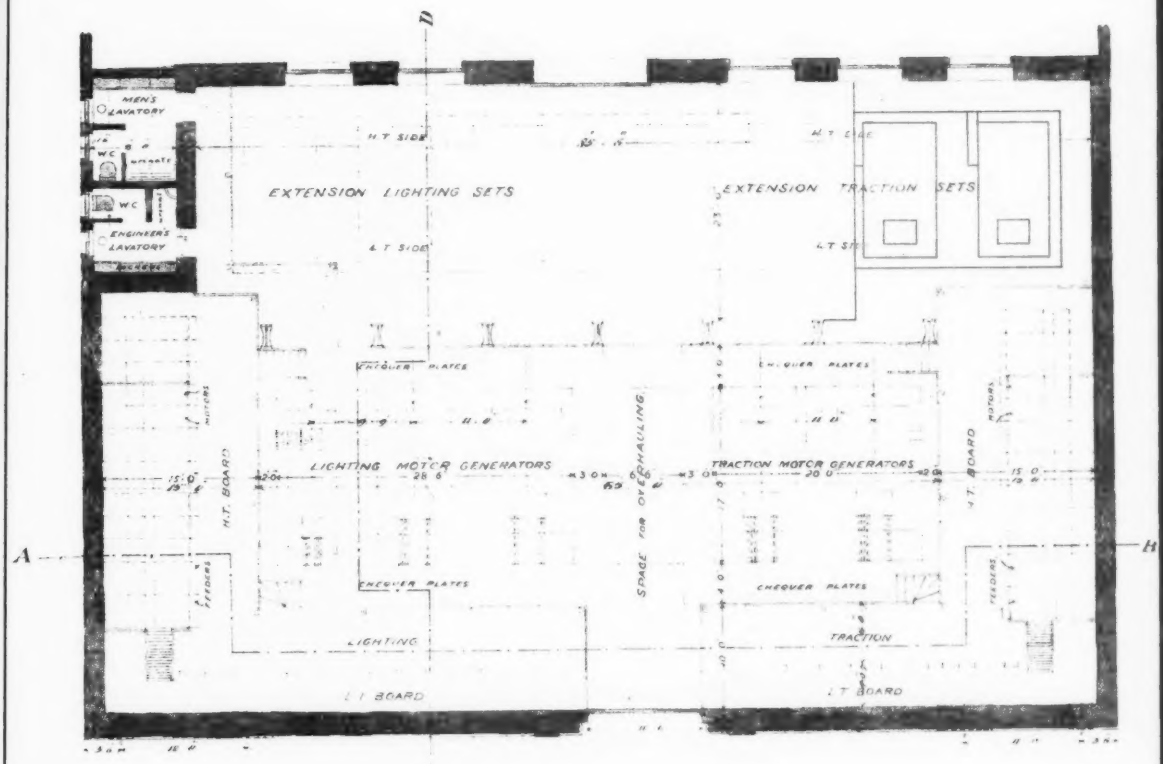


down on Transformer Galleries and Main Floor



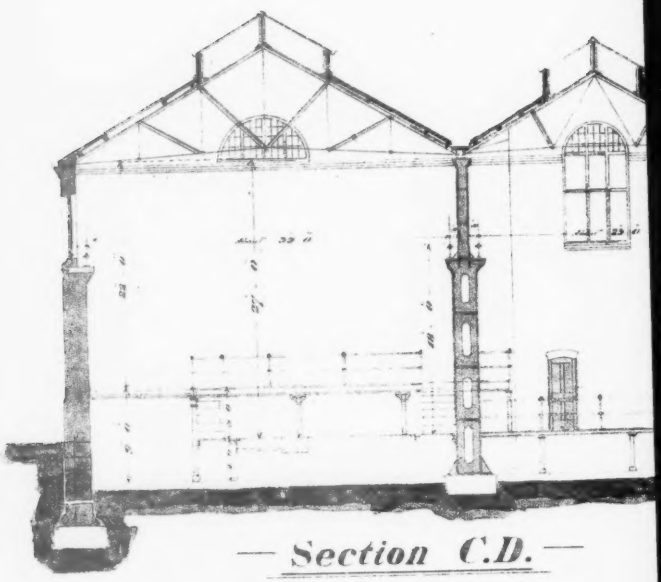
Plan of Lower Battery Floor

C.F.KELL & SON, LITH 8, FURNIVAL ST HOLBORN, E.C.



Ground Plan.

BENNETT STREET SUB-STATION OF THE M



— Section C.D. —

ANCHESTER CORPORATION

KENNEDY &
Engin
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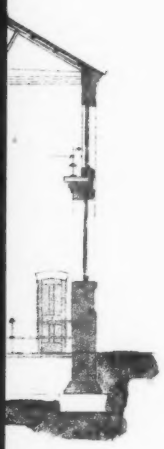

JENKIN,
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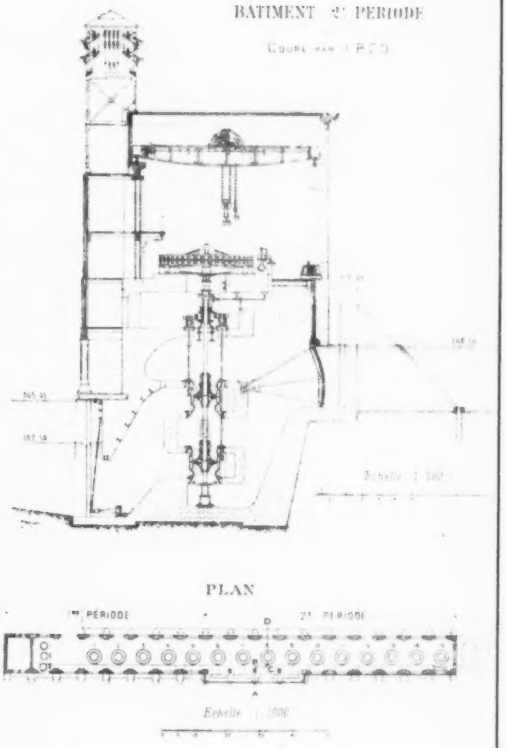


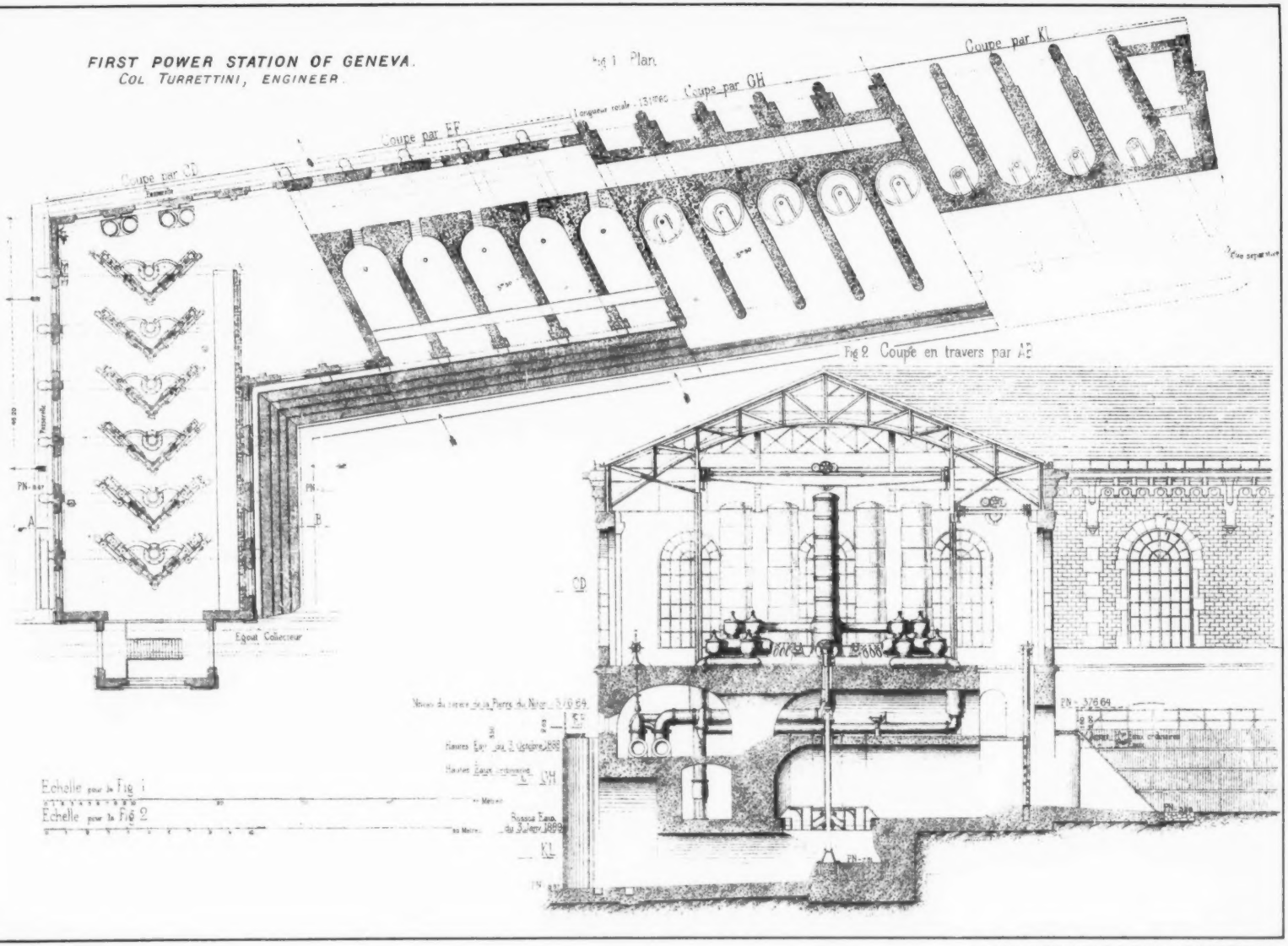
SECOND WATER POWER STATION OF GENEVA, AT CHÈVRES

COL. TURRETTINI

C.F.KELL & SON, LITH. 8, FURNIVAL St. HOLBORN E.C.

FIRST POWER STATION OF GENEVA.

COL TURRETTINI, ENGINEER.

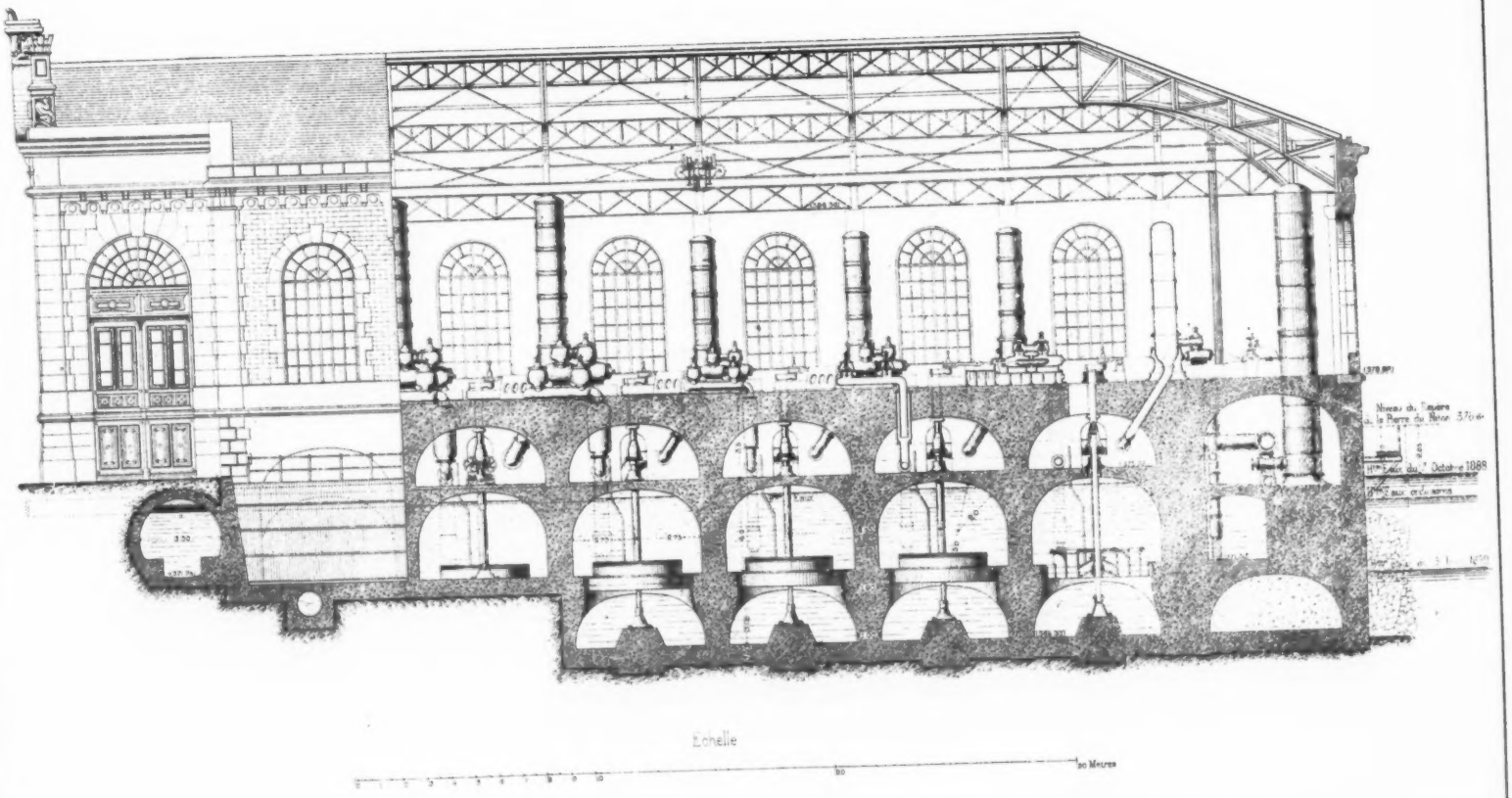


C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

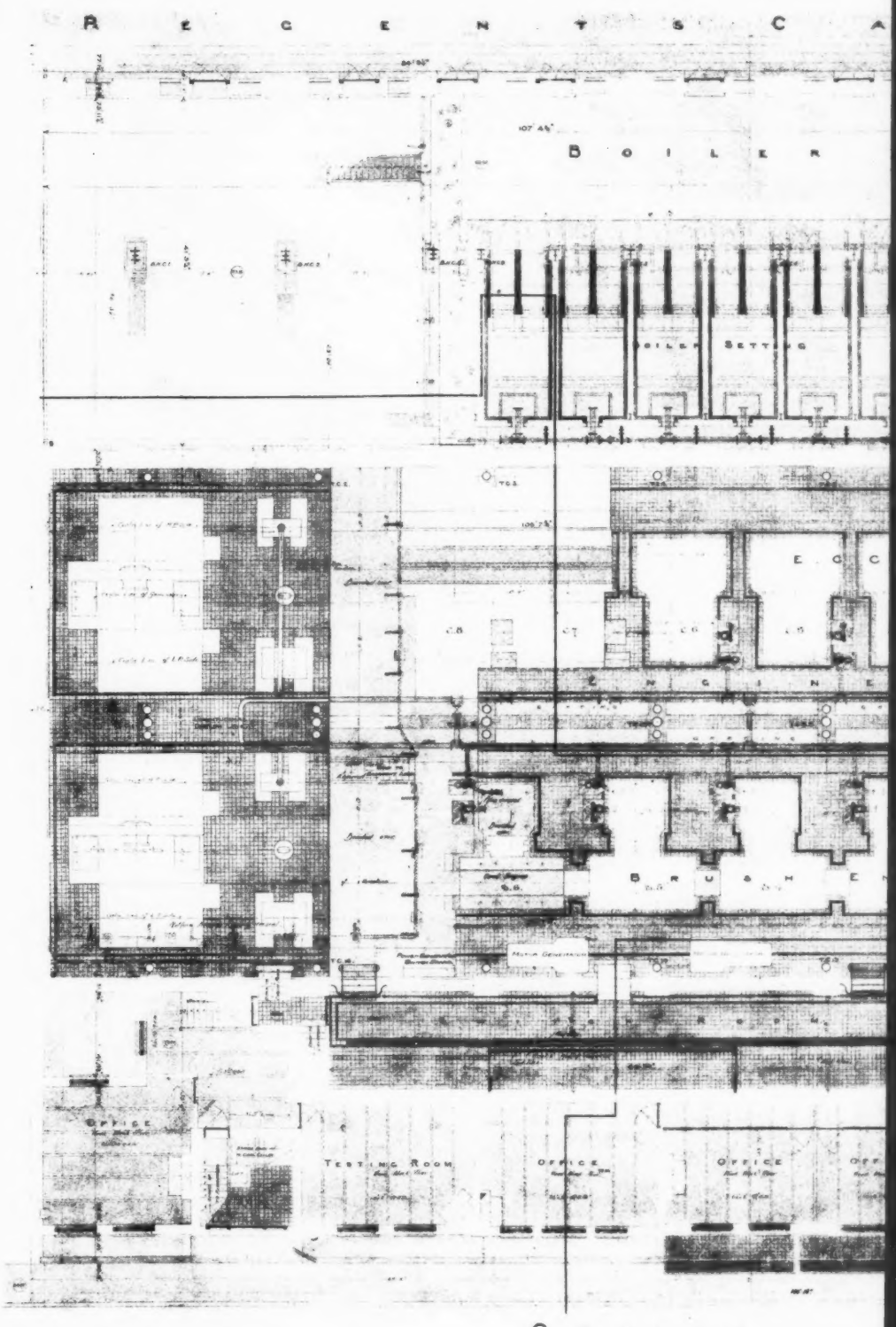
FIRST POWER STATION OF GENEVA.

COL TURRETTINI, ENGINEER

Elevation et Coupe longitudinale

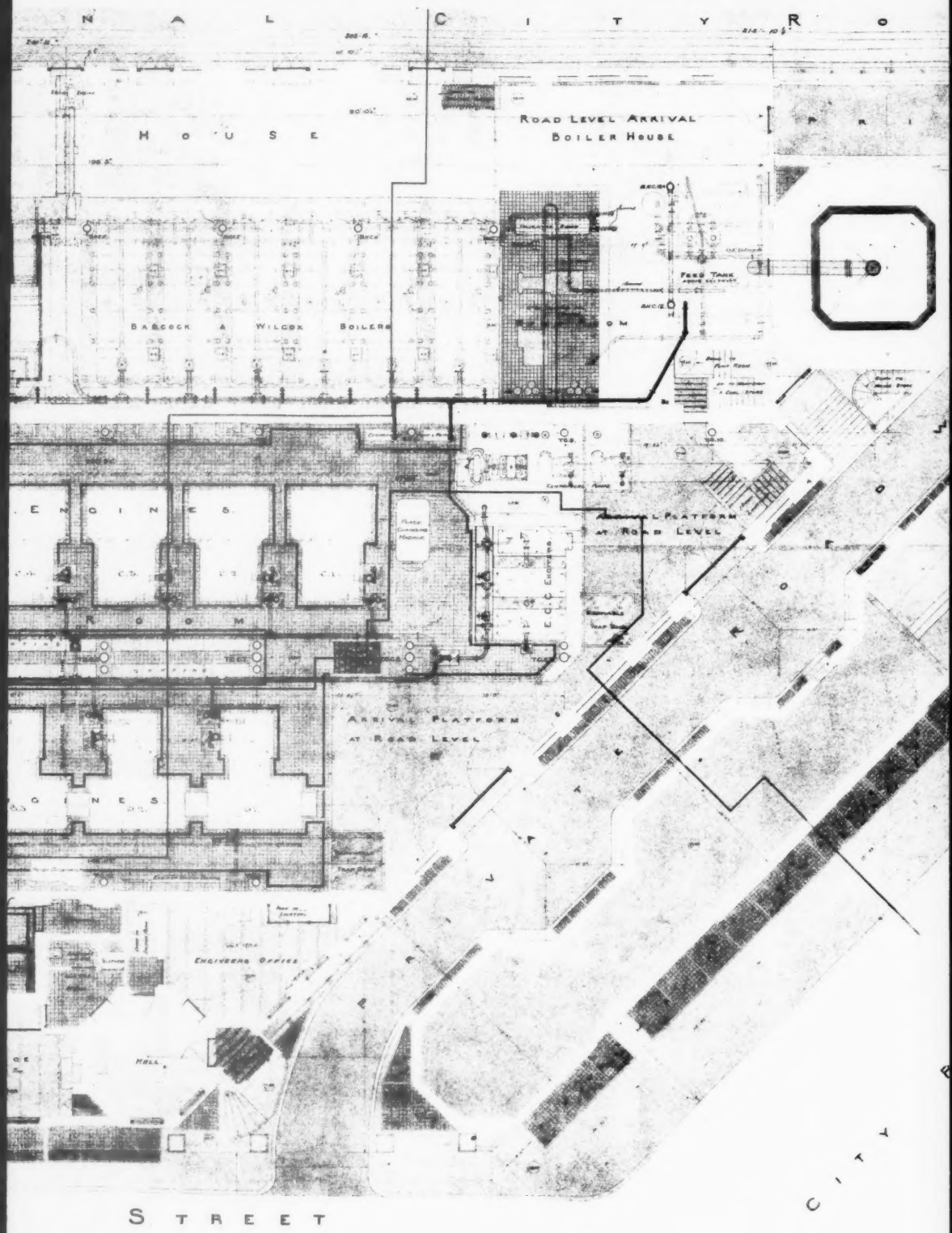


C.F.KELL & SON, LITH. 9, FURNIVAL ST HOLBORN, E.C.

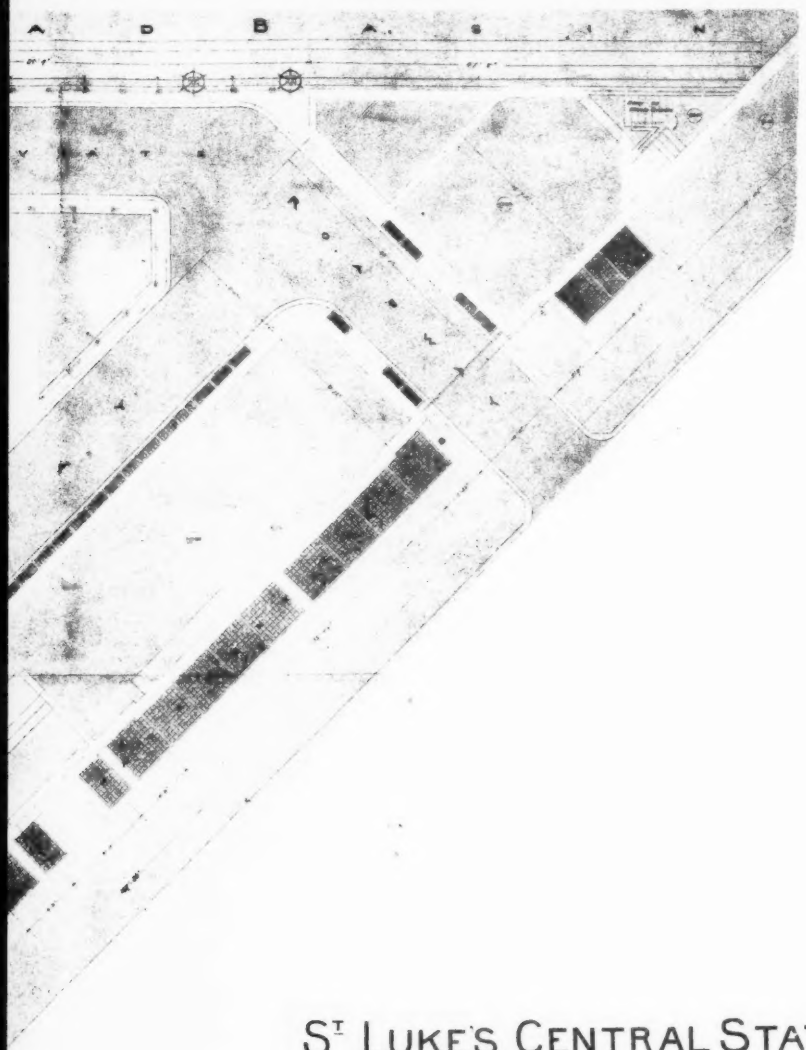


A.J. LAWSON,
Engineer

—— Plan taken principally at Gro



nd Floor Level.——



St. Luke's Central Station.

Oak Wharf - City Road . E.C.

For The County of London and Brush Provincial Electric Lighting Company Ltd

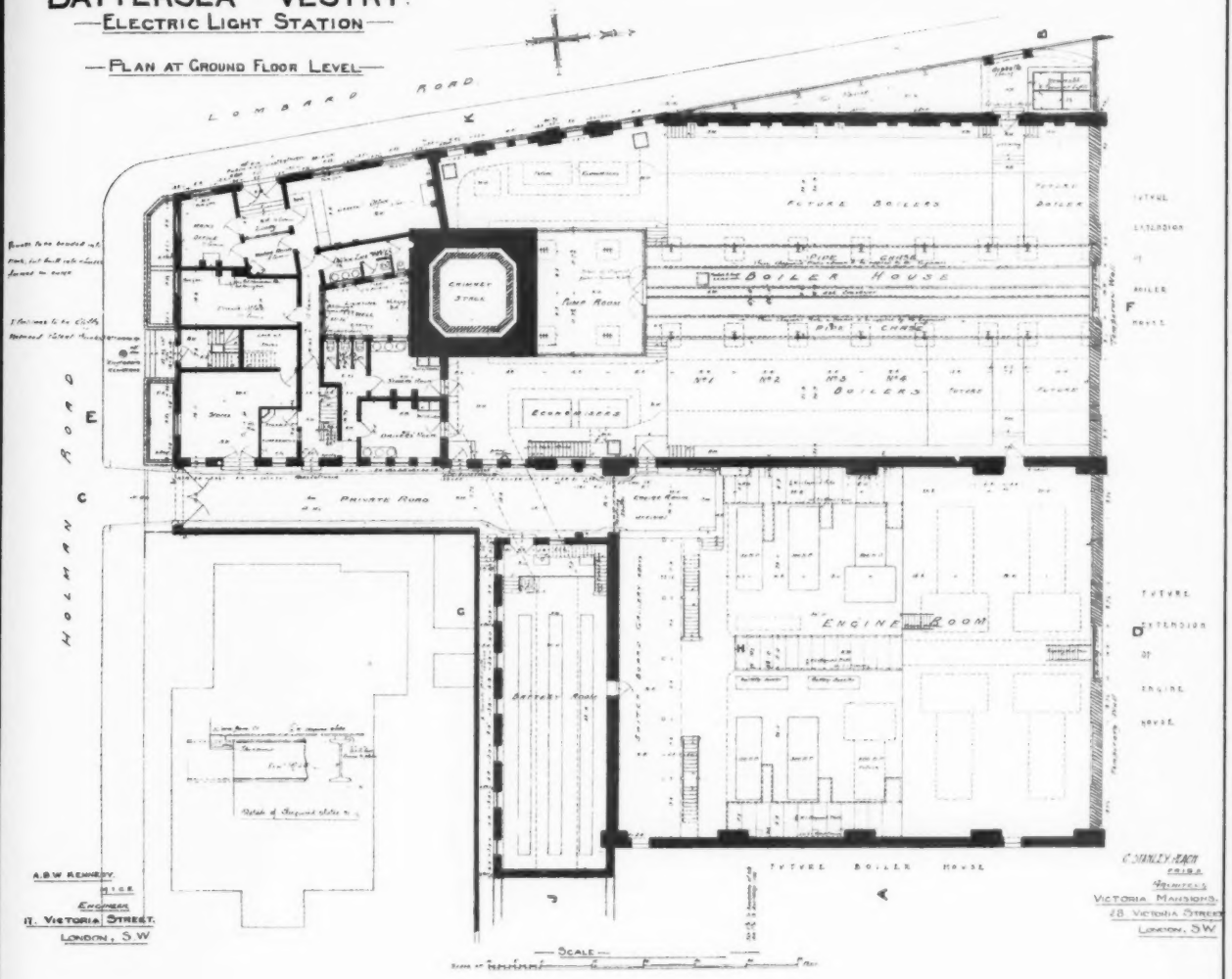
C. Stanley Peach, F.R.I.B.A.
Architect,
28 Victoria Street, S.W.

C.F. Kell & Son, Lith. 8, Furnival St Holborn, E.C.

BATTERSEA VESTRY.

—ELECTRIC LIGHT STATION—

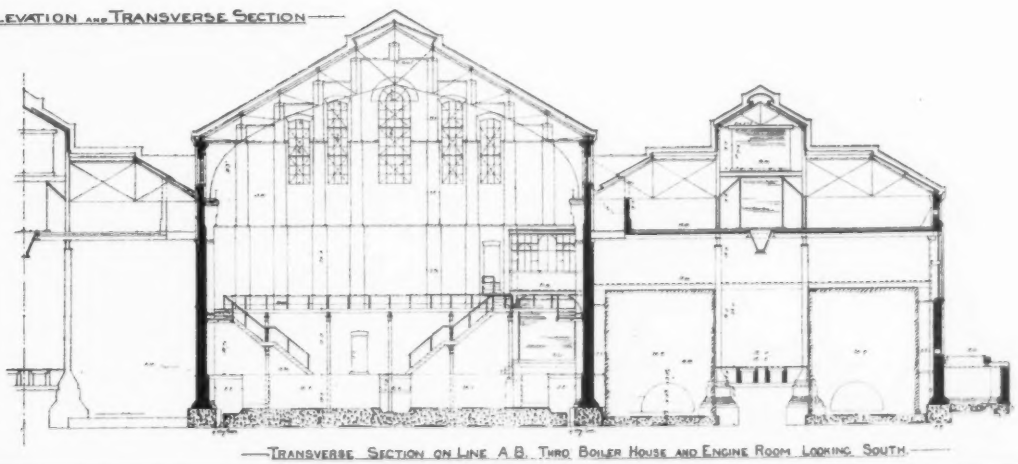
—PLAN AT GROUND FLOOR LEVEL—



A.B.W. KENNEDY. M.I.C.E.
ENGINEER.
17, VICTORIA STREET.
LONDON, S.W.

C. STANLEY PEACH F.R.I.B.A.
ARCHITECT.
VICTORIA MANSIONS.
28, VICTORIA STREET.
LONDON, S.W.

—ELEVATION AND TRANSVERSE SECTION—



—TRANSVERSE SECTION ON LINE A.B. THRO BOILER HOUSE AND ENGINE ROOM LOOKING SOUTH.—

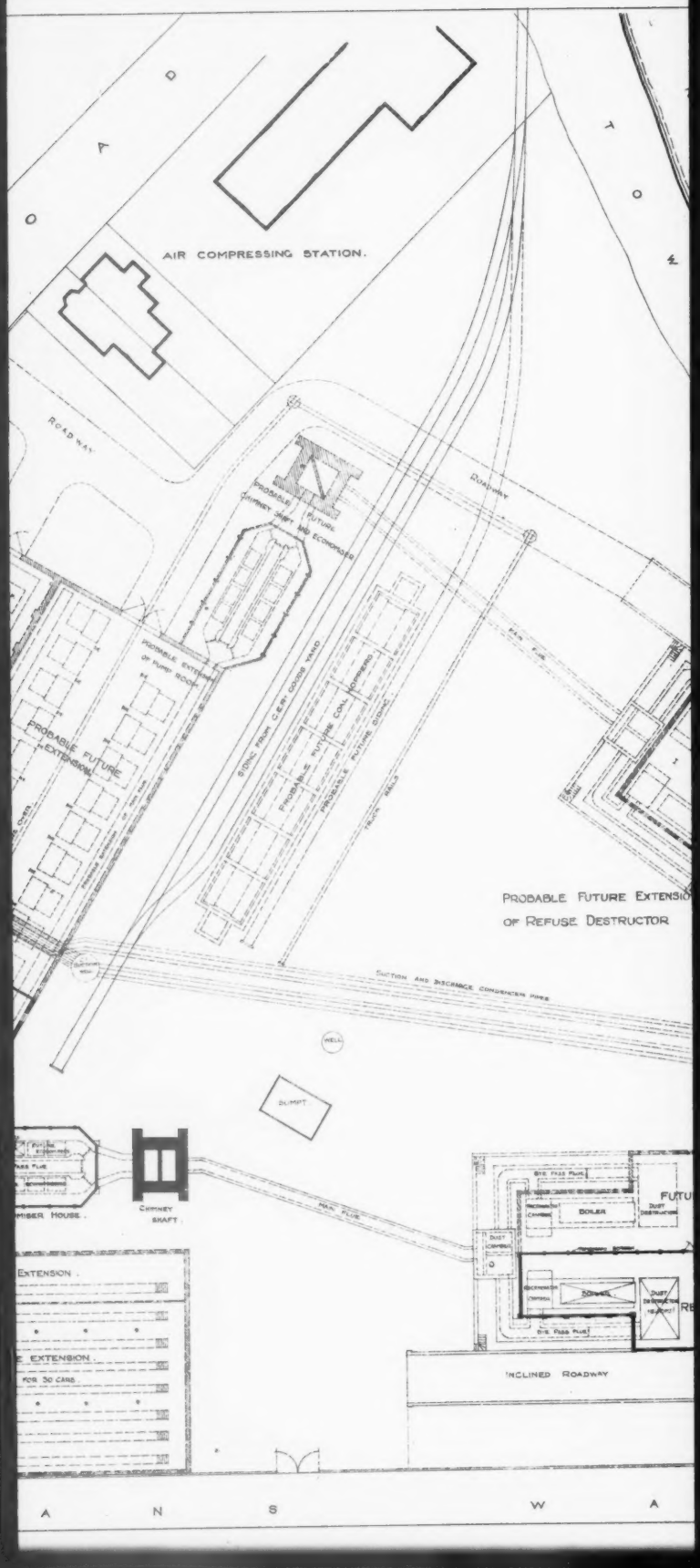
C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

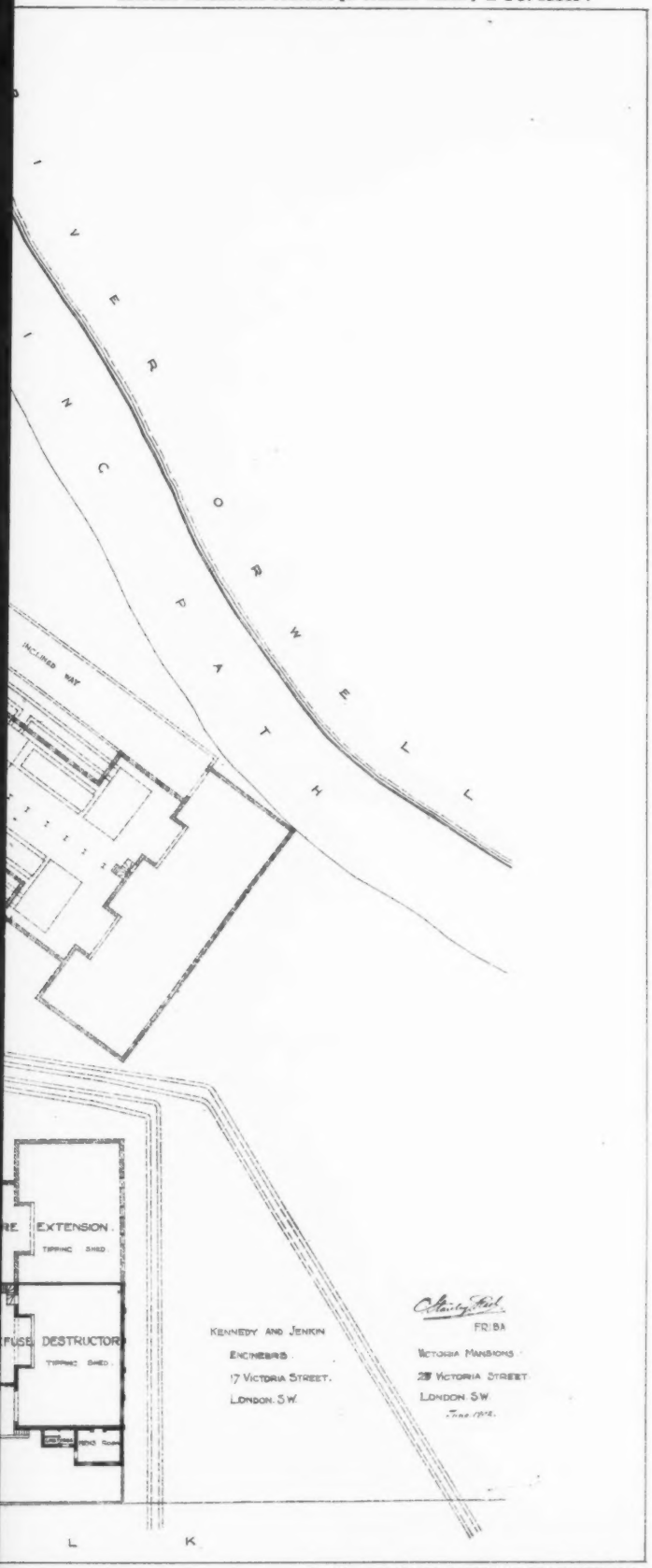
IPSWICH CORPORATION.

ELECTRIC GENERATING STATION.

PLAN OF PRESENT AND FUTURE BUILDINGS.

SCALE 16 FEET TO 1 INCH.


AIR COMPRESSING STATION.
ROADWAY
ROADWAY
PROBABLE FUTURE CHIMNEY SHAFT AND ECONOMISER
PROBABLE EXTENSION OF PUMP ROOM
PROBABLE FUTURE EXTENSION
STONE FROM DEEP GOODS YARD
PROBABLE FUTURE COAL HOPPERS
PROBABLE FUTURE STORES
MAIN FLUE
PROBABLE FUTURE EXTENSION OF REFUSE DESTRUCTOR
SUCTION AND DISCHARGE CONDENSER PIPES
WELL
SHAFT
MISER HOUSE.
CHIMNEY SHAFT
MAIN FLUE
EXTENSION.
E EXTENSION.
FOR 30 CARS.
BYE PASS FLUE
BOILER
DUST CHAMBER
DUST DESTRUCTOR
BOILER
BYE PASS FLUE
INCLINED ROADWAY
A N S W A

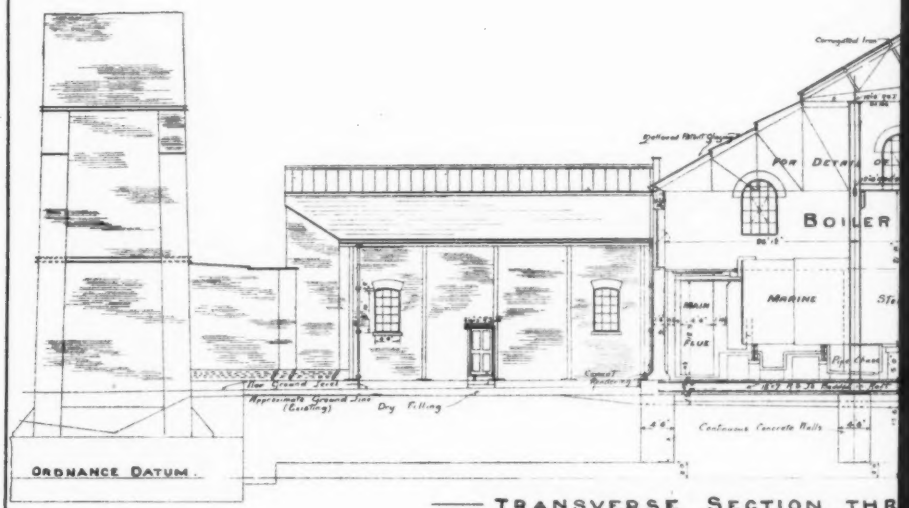


C.F.KELL & SON, LITH. 8, FURNIVAL ST HOLBORN, E.C.

— IPSWICH CORPORATION — ELECTRI

— TRANSVERSE SECTIONS —

SCALE 8 FEET TO 1 INCH



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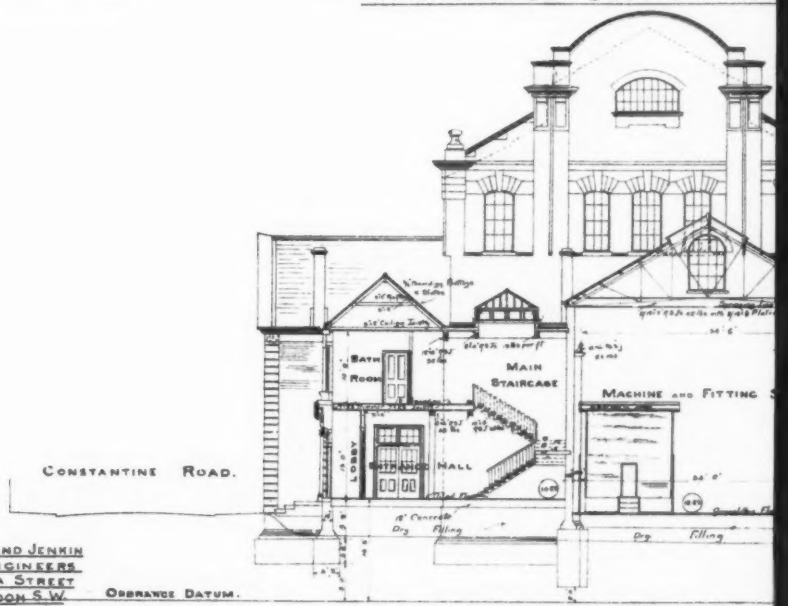
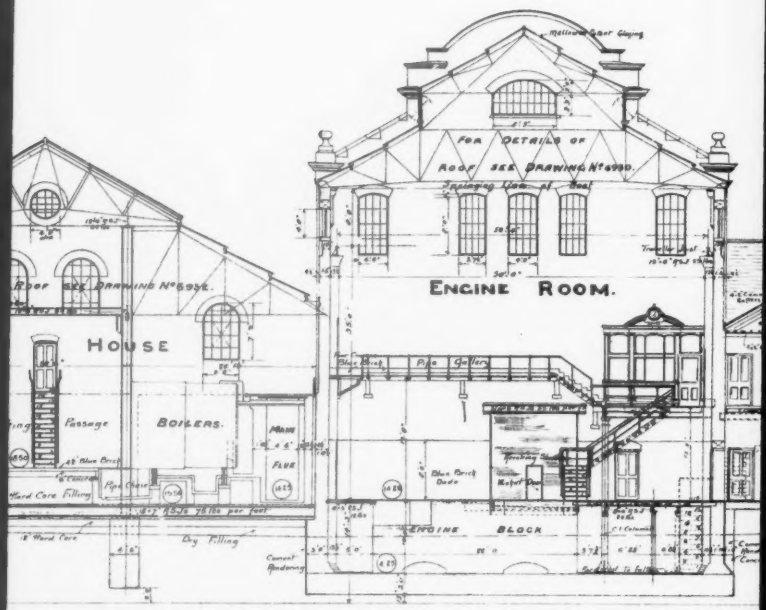


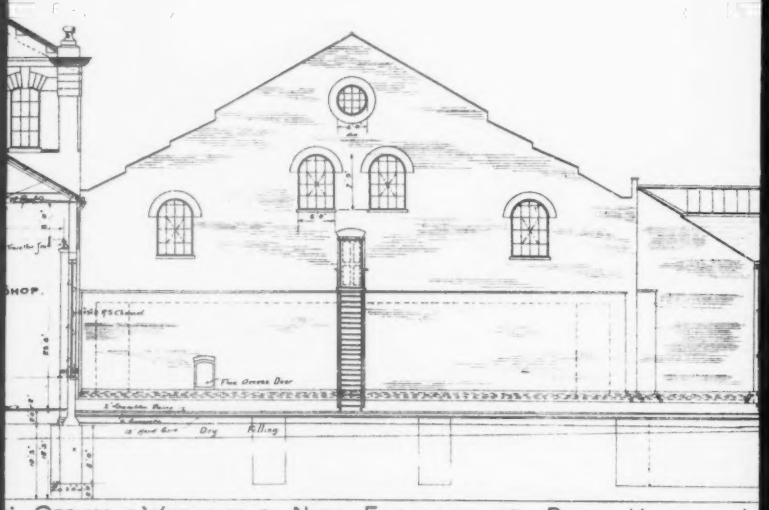
KENNEDY AND JENKIN
ENGINEERS
17 VICTORIA STREET
LONDON S.W.

— TRANSVERSE SECTION THR

C GENERATING STATION —



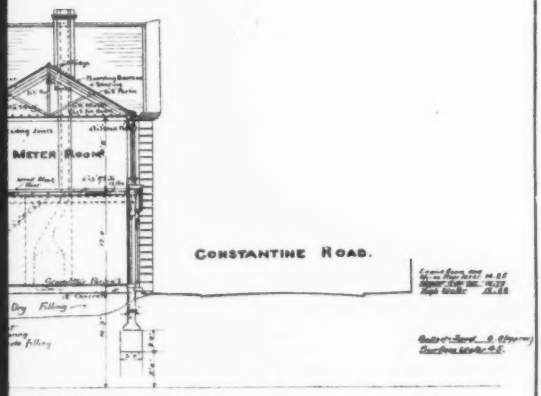
O' BOILER HOUSE AND ENGINE ROOM ON LINE E



O' OFFICES & WORKSHOP & NORTH ELEVATION OF BOILER HOUSE ON L

DRAWING Nº6921

COPY SENT TO — DATE



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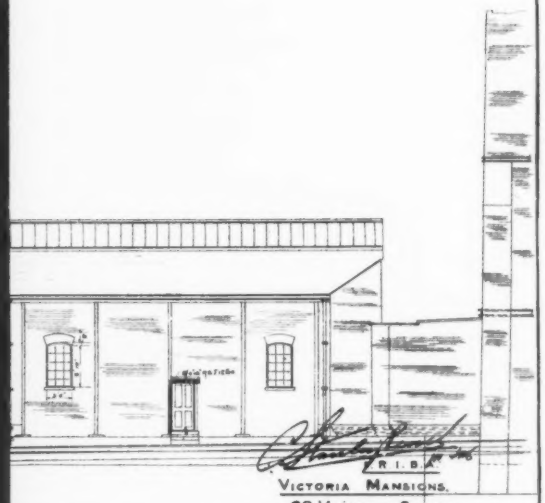
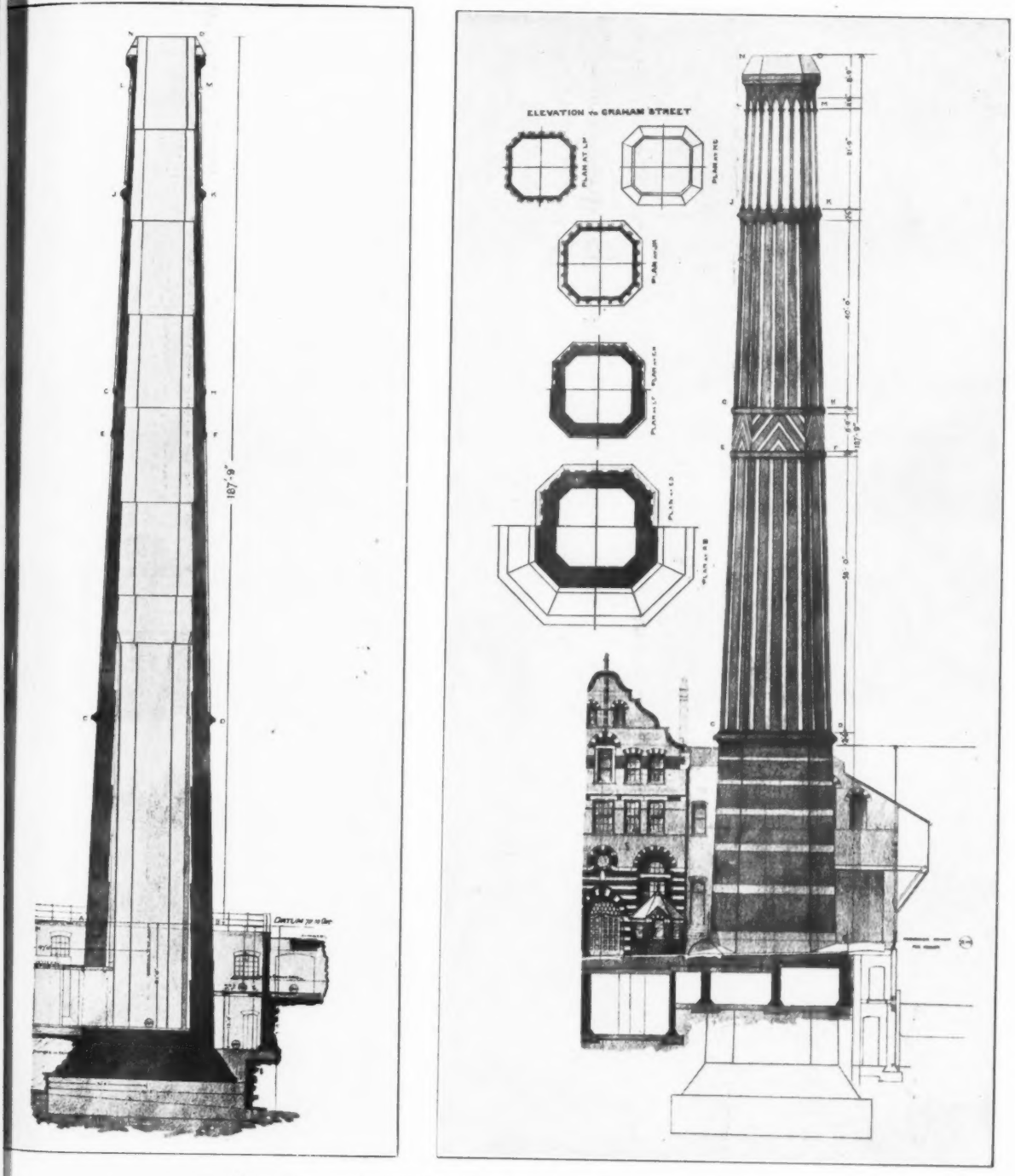


R.I.B.A.
VICTORIA MANSIONS,
28 VICTORIA STREET
LONDON S.W.

INE C-H.

JULY 1902

C.F.KELL & SON LITH 6, FURNIVAL St HOLBORN, E.C.



FIGS. 16 AND 17.—ST. LUKE'S CENTRAL STATION, OAK WHARF, CITY ROAD, CHIMNEY SHAFT.

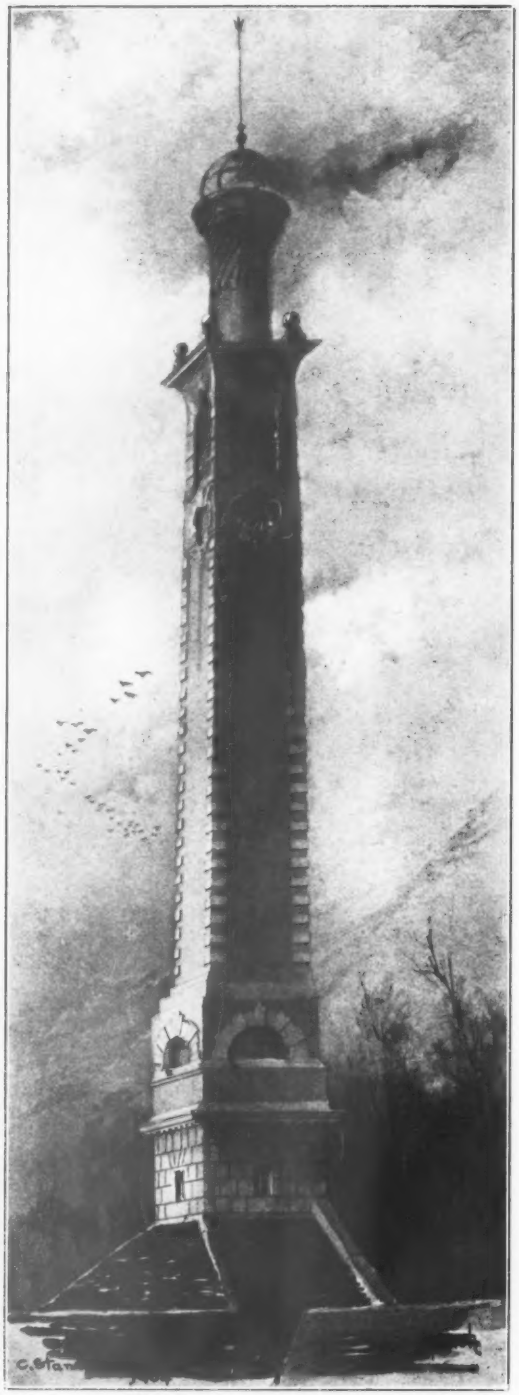


FIG. 18.—THE CHIMNEY SHAFT OF THE ELECTRIC-POWER STATION, MUNICH. (FROM A SKETCH.)

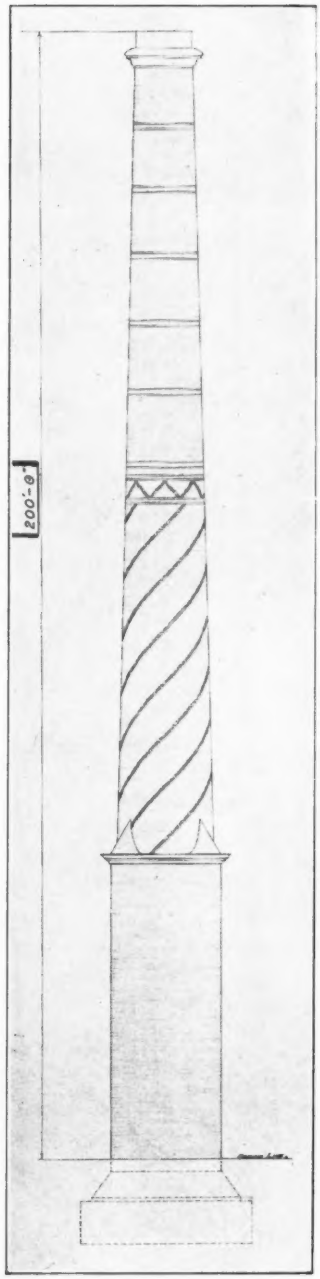


FIG. 19.—HALLE ELECTRIC-POWER STATION, CHIMNEY SHAFT.

the most that happens to a shaft of unquestionable stability is a slight immeasurable shiver when struck repeatedly by powerful gusts of wind. In almost every case where anything like reliable evidence is forthcoming of a stack having been seen to sway, it is also proved that it was not strong enough to withstand the force of the wind acting on it for it has either subsequently fallen, or been blown so far out of the perpendicular that it has been necessary to pull it down.

There is a common saying among steeplejacks that a heavy cap on a chimney shaft acts as a weight at the end of a lever, and so produces the destruction of the shaft. It is possible that such a thing might have happened, but it is improbable. As a rule the opposite is the case, and the so-called heavy cap has assisted in keeping an otherwise unstable shaft from falling. If the shaft has eventually failed it was because it was so insecure that even the weight of the cap could not save it. Cast-iron caps are frequently objected to as being heavy; properly designed, they are lighter than a corresponding height of brickwork. Within reasonable limits a fairly heavy cap is an advantage and not a disadvantage.

It is sometimes said that a better draught is created by a circular than by a square stack. In this case also, actual measurement shows the contrary to be the case. For stacks of equal power the evidence, on the whole, is in favour of the square stack, both as regards stability and appearance, and also as regards cost.

It remains only to summarise briefly a few matters which experience has shown are of importance in designing central stations. These buildings serve an important public purpose, and the work when once started must be carried on continuously day and night. They must therefore be incombustible in every part, and since it is not known how serious an electrical fire may be, they should be designed on the compartment or independent bay system, so that the disablement resulting from a fire may be limited. Every material can be destroyed by a powerful arc; it is, therefore, advisable to keep the main supports of the building as far away from the electric conductors as possible, especially by the switchboard. No materials which under any circumstances can burst into flame should be used, and especially the use of woodwork in both engine room and boiler house roofs should be avoided. Every department should be cut off as completely as possible from every other department, having regard to the work which is to be performed; but a sufficient number of exits, at least two, wide apart, should be provided to every department in which there are steam pipes, boilers, electrical, or moving machinery. Unequal temperatures constantly changing are unavoidable in different departments, and in many places these temperatures are very high. Ample allowance should therefore be made for expansion and contraction everywhere, especially in chimney shafts, boiler settings, main flues, and in the boiler house generally.

Vibration, varying in intensity with the type and speed of the engine, is present in all these buildings. It is not necessarily transmitted beyond the building itself, but it has been felt at a considerable distance, and many curious results have been observed. With alternating current dynamos direct coupled to engines, the effect can to some extent be regulated by the manner in which the plant is worked; but this cannot be done with continuous current or belt-driven plant. In any case it is by no means sufficient to rely on. The position, shape, size, weight, and rigidity of the foundations have a material effect on the amount of vibration which is noticeable in the building and transmitted beyond it. With some kinds of engines practically nothing which the architect can do has any appreciable effect in controlling or reducing the vibration, but with most engines a great deal can be done. Many kinds of so-called elastic, resilient, or cushion foundations have been tried, but so far none have proved successful with large engines, nor is there any evidence that vibration has been diminished by them.

Results obtained with small experimental machines are no guide to what will happen with several large machines. Foundations unevenly loaded, or fixed at one end and free at the other, and concentrated loads on girders high up in the building, increase vibration, and are apt to cause it to extend beyond the building. These are forms of construction to be avoided wherever possible. The vibration produced by a number of engines in step, or "galloping," as it is called, is frequently prevented by forming deep indents in the bottom of the foundations, and a wide area at the bottom of the engine block. Engines are frequently placed too close together, and consequently sufficient width of foundation to absorb vibration cannot be obtained. Separation of the engine foundations from the main structure is useful, but difficult to carry out effectually; but modified separation, combined with sufficient weight, spread of base, and extreme rigidity of foundations have on the whole proved to be the most efficient methods of dealing with this troublesome factor.

Repairs are expensive, difficult, and dangerous to execute, therefore only the best materials and workmanship should be used as tending both to efficiency and economy. The buildings are sure to be altered and enlarged as time goes on, whatever the first idea of the future size may be; therefore, the part first erected should be of sufficient strength to admit of this being done, without interfering with the existing building or plant installed and working.

Power stations must be erected where power can be generated cheaply, and sub-stations and direct supply stations in cities and among other buildings. Beyond some small custom which they may bring to local tradesmen, they do not, as a rule, benefit the place in which they are erected. By many they are considered worse even than motor cars, and as nuisances and abominations, standing where they ought not, more particularly when the power generated is for another district for which those dwelling in the vicinity of the station care nothing. But the value of the property in the district where the power is used is enhanced; the profits of the undertaking go to individuals who live in other places. The persons living round the station are naturally jealous, and consider themselves aggrieved, for they are inflicted with the works that others may reap the benefit. This accounts in a great measure for the hostile attitude they frequently adopt.

In designing these buildings the amenities of the locality should not be disregarded, and every care should be taken to reduce to a minimum all causes of nuisance or annoyance. The appearance of the building counts for much in these cases, and frequently sites can be obtained on favourable terms; hostility, expense, and litigation can be avoided by bearing in mind, when working out the design, that a little additional capital expenditure on the building for the benefit of the surrounding property has no prejudicial effect on the success of the undertaking, either in its early stages or later on. On the contrary, it is much more economical than purchasing property when an injunction has been obtained, or paying compensation for nuisance or the costs of a lawsuit. In the one case the only assets in return for a large entry in the balance sheet are, a good crop of ill-feeling against the undertaking, much valuable time spent on litigation which could have been better employed for advancement of the business, perhaps a learned judgment, and many bundles of papers. When the other course is followed, as at Tivoli, Munich, Geneva, and many buildings abroad—some in the United Kingdom—the capital expenditure is a negligible fraction compared with the total cost. In return, there is a profit to those earning a living in the locality, good feeling among the neighbours, a more valuable building for the owners, a reduction in the cost of maintenance, something to show that the people of this generation, while inheriting the commercial instinct of those who founded the Hanseatic League, have not lost the art of combining the useful with the æsthetic in the design of buildings of the warehouse class.

This is no Utopian dream of what might happen if these points are taken into account

in the design. They are statements of what has occurred when the two courses have been adopted in actual practice in several instances. The alternatives can be reduced to a common denominator of £. *s.* *d.*, and a fair comparison can and should be made when the design and estimate are being prepared.

It has only been possible to treat the subject very generally in these notes, and to give an idea of what these buildings are. No doubt opinions differ considerably on almost every point connected with them. This is only natural considering how modern they are, and how much connected with them at present rests rather on individual experience of isolated cases than on well-ascertained and widely tested data.

In central stations, as in many modern buildings, the co-operation of two professions concerned with completely different subjects is necessary, viz. building and mechanical engineering. Where such a wide difference exists no rivalry is possible, and excellent results have followed from the collaboration which has been the custom in this industry.

From the very commencement of electric supply engineers have been ceaselessly engaged in inventing, working out, and perfecting the innumerable electrical and mechanical devices and systems connected with this highly scientific subject. It has been, and it is, impossible for them to burden their minds or give up time to the consideration of the buildings. From the moment that the plant arrangement which the engineer requires has been given to the architect, the former never expects nor wishes to have anything more to do with the buildings until the architect is in a position to hand them over ready for the engineer's work to commence and plant to be erected. By this it is not to be understood that during this time the architect can work without reference to the engineer ; quite the contrary. They must be in touch at every point from commencement to completion. The architect must be prepared to deal with the legal points affecting the buildings, their cost, and every part of the construction. He must appreciate what the industry is, what its developments are likely to be, and have the same intelligent general knowledge about machinery and things electrical that he would be expected to have of the fittings, appointments, and work of any other class of buildings more commonly met with in general practice.

The work of the electrician and the mechanical engineer is undoubtedly the most important, since they are concerned with working out, inventing, and perfecting the system of supply, the machinery and plant, and all that is in motion, which is the very life of the industry. The architect has but to construct the frame, which must uphold, support, and protect the vital organs, and to give some suitable outward expression of the wonderful and useful work carried on within the structure. Many of these buildings are yet to be erected, and many opportunities lie before those who realise that as men's minds widen with the process of the suns, the interest of the modern problem is to dip

> "Into the future, far as human eye can see,
> See the vision of the world, and all the wonders that will be."

DISCUSSION OF MR. PEACH'S PAPER.

The President, Mr. Aston Webb, R.A., F.S.A., in the Chair.

Professor ALEX. B. W. KENNEDY, LL.D., F.R.S., who rose at the invitation of the President, said he hoped the architectural profession were seriously taking this matter up. These stations had to come, and, if architects would not attend to them seriously, so much the worse for the stations, and so much the worse for the public who had to look at them. As Nature had not provided water power in this country, they would have to put up with high chimneys, and if

engineers had to design them, the consequences would be too appalling to think of. He hoped, therefore, that architects would take up this subject in the spirit in which Mr. Peach had taken it up. A rather serious, though characteristic, fault he had to find with Mr. Peach's Paper. He could see nothing of his name in the whole Paper; he had said nothing whatever, in describing the buildings on the screen, as to what he had done himself. He should like to supplement this, and to have it on record that a very large number of the stations he had shown were of Mr. Peach's own design. For instance, the Westminster Electric Lighting Company, the St. James's and the Central Electric Company's stations, the County of London and Brush, that beautiful station at Ipswich, and many others which Mr. Peach had laid no claim to, though he had given ample credit to other people's work. As to the relations between engineers and architects in work of this kind, Mr. Peach had indicated them in a very satisfactory manner. The work of the two branches must necessarily be close, and neither could get on without the other if a thoroughly satisfactory result was to be obtained. He would emphasise two or three points in which engineers looked to architects to help them. He did not speak of the exterior arrangements because there they looked to architects to help them altogether. The more the engineers could be assisted by the architects in this matter the better for everybody concerned; and in one respect at least, as Mr. Peach had said, the more largely the buildings were conceived the better the financial result would be, and the more lasting would be the buildings. The question of vibration was a very serious one in buildings to be erected in towns; therefore the construction of the foundations, so as to have as little transmission of vibration as possible from the inside of the building to the outside, was one of the most important things the architect could have to consider. He was partly at the mercy of the engineer in this matter—because the engineer had to have the foundations more or less of a particular shape. But, from his own experience, perhaps the most important point in the matter of getting non-vibrating foundations, apart from the fact that they should be separate from the foundation walls, was that, if possible, they should be rather of the shape of a flat tile put down flatwise than of a brick set up on edge—that is, they should be of a shape which should offer as little chance of rocking on its own corners as possible. He had found in one or two cases of great importance that the trouble with foundations had been essentially that they were made somewhat in the shape of a brick set up on edge, very high, and, comparatively speaking, very narrow; and he had no doubt that, in certain cases, what had happened had been that the foundations had rocked from corner to corner, and the rocking had been transmitted across streets and into neighbouring premises in a most uncomfortable fashion. The plan he thought Mr. Peach had adopted had been, after the concrete was laid in the usual way, to lay a sort of sand keys, ten or twelve feet square, with six or eight inches between in all directions; so that the bottom of the main engine foundation floor was not flat, but had a number of grooves in it, which were filled up with a non-adhesive material, separating it more or less fully from the concrete below, and making it very difficult for it to rock as a whole. He could not say that this construction had been the cause of their having had so little complaint of vibration in some of the stations Mr. Peach had put up in central London, but, if it had not been the cause, at any rate they had not had any trouble with vibration, and the foundations were constructed in that fashion. Another matter of the very greatest importance, which they were now only beginning to realise, was that they must have no combustible materials about the building. They used to say that it was sufficient if they had nothing in the building that would burn. But that was not enough now. Other buildings might burn and set the roofs of their stations on fire; and now they had to ask that architects should supply them with buildings which practically had nothing about them that would burn, no matter what wickedness the engineers were guilty of by way of trying to set them alight from inside. The construction of these huge buildings in the County of London was undoubtedly rendered much more difficult, and much more expensive, by certain conditions of the Building Act, or interpretations of the Building Act. He hoped that in time some reforms might be introduced into that Act which would allow them to deal with these buildings—which were never contemplated ten or fifteen years ago—in a more reasonable fashion. In conclusion, he could only say that members of both professions must look upon Mr. Peach's Paper as most valuable, and as a singularly complete description of matters of the greatest importance to them.

COLONEL EUSTACE BALFOUR said he was in a somewhat difficult position; though he happened to be an architect he happened also to be in a different relation to Mr. Peach, as Chairman of the St. James's Electric Light Company, and Vice-Chairman of another Electric Light Company, and also as Surveyor to the Grosvenor Estate, having a knowledge of his work on that estate. It therefore gave him very great pleasure to be able to speak on this subject, although he was not speaking just now as an architect, but rather as one having knowledge of Mr. Peach's work in electric light concerns. Some years ago he went very carefully into the question of water

power with Lord Kelvin, and he asked him whether he could by any possibility find a means of using the Scottish sea lochs for water power. Lord Kelvin replied that he had gone into his figures completely, and that it was absolutely out of the question. Therefore it might be laid down as a principle that, so far as water power was concerned in electricity, it was only in those cases where there were great rivers, like Niagara or the Zambesi, running permanently, or, in the other set of cases, like the Swiss rivers from the snow mountains, or in New Zealand from the snow mountains, that one could expect to use water power as a permanent source of energy. That meant a great deal; it meant that in North Italy, in New Zealand, and in certain parts of South Africa, an equivalent of coal existed in the snow mountains or elsewhere. That was a purely engineering point. They had also to consider how architecture was to be dealt with in these stations; and Mr. Peach had shown how the buildings should be treated. Their great problem was the problem of chimneys. Two or three months ago, Lord Wemyss, who, he believed, was a member of the Institute, came into his room at home and saw a photograph of one of those chimneys at St. John's Wood, and said it was better than the Campanile of St. Mark's at Venice! He (Col. Balfour) honestly believed that it was possible to design chimneys which would in themselves be beautiful; and he congratulated Mr. Peach on having been the first to deal with that situation, and whether successful or unsuccessful (he himself thought successful), at any rate to have tackled a problem which was as difficult a one as there could be. As regards the relations between architects and engineers, those relations became more complicated every day. They began in the days of railways, when the engineers thought they could design beautiful buildings; then they came to consider that they could not do it; and they began to try and combine with the architects. There, he thought, the Germans were a little ahead of us. The Frankfort Railway Station, one of the most beautiful structures in Europe, was the combined work of engineers and architects. Engineers and architects ought to work together; the one to supply the artistic side, and the other the engineering. With regard to the construction of the electric light stations and the vibration in the neighbourhood, they must clearly have legislation. The present legislation, he thought, was insufficient; but that was a practical point, and somewhat outside the architectural side of the question.

Mr. JOHN SLATER [*F.*] said he had had some little experience in building electric lighting stations, but not to anything like the extent that Mr. Stanley Peach had; moreover, those for which he was responsible were mostly in the early days of electric light, when they knew very much less than now. He should like to echo Professor Kennedy's remarks about the extreme modesty of Mr. Peach's Paper, for he had given no indication as to which were his own buildings among those he had shown on the screen. He was quite sure that everyone would agree that they ought to pass a very sincere vote of thanks to him for the enormous trouble he had taken in bringing this subject before them. There was no doubt that if they could have water power for use in their stations it would greatly simplify matters. He had been over one of the stations at Freiberg, which was driven entirely by water power supplied by one of the small streams alluded to by Colonel Balfour; and he could not help remarking the extreme cleanliness of the whole place from the absence of coal. Here, however, we were compelled to use coal. With regard to large generating stations, he was of opinion that it was not desirable to have them in thickly populated parts of cities at all. The tendency of electric lighting companies in London had been to go beyond the crowded districts, and to get sites which would not interfere with the amenities of the neighbourhood. Several of the concerns with which Mr. Peach was connected were going further afield. The Kensington and Knightsbridge, and the Notting Hill, for both of which companies he (Mr. Slater) had built stations some years ago, had found that the nuisance of having them in the midst of crowded neighbourhoods was so great that they combined to secure a site at Shepherd's Bush, where they had erected a joint station very much on the lines of those shown them by Mr. Peach. This, of course, necessitated the construction of small distributing stations, which could be more easily brought into agreement with the surroundings than was possible with the large stations. The question of vibration which had been touched on was a very serious one indeed; if the central stations were in crowded localities trouble was almost bound to ensue. He did not think the engineers had been quite able to explain satisfactorily the curious vagaries of vibration. At the station he had built at Notting Hill, all the engines were put in a very deep basement on the hard London clay, yet they found that the vibrations affected, not the houses immediately contiguous, but those a street and a half off. That he believed had been the experience of others. They satisfied themselves at Notting Hill that the vibrations were not solely earth vibrations, but air vibrations, and no doubt those could be more satisfactorily dealt with.—Mr. Slater concluded by proposing a most hearty vote of thanks to Mr. Peach, which was seconded by Colonel Eustace Balfour.

Mr. FERRANTI said he thought the Paper was intensely interesting, and most valuable both to engineers and to architects as a record of what had been done in central station practice. To

meet the wants of the present day—wants which were constantly growing—it was most valuable to have an accurate record of what had been done up to date. Such a record had been given them very fully in Mr. Peach's admirable Paper.

THE PRESIDENT suggested that the occasion afforded a good opportunity to ask Mr. Stanley Peach for any further information on the subject.

COLONEL EUSTACE BALFOUR asked if Mr. Peach would tell them something about the Berlin installation.

MR. A. MARYON WATSON [*A.*] asked if Mr. Peach would tell them what means they should adopt in designing the brick linings of steel shafts to allow for expansion and contraction.

MR. A. WRIGHT asked if Mr. Peach would give his impression as to the best means of dividing risks. In the case of a boiler house, for instance, it was obviously very necessary to provide against the bursting of a steam pipe, shutting down the whole boiler house; and the same sort of security should be provided for in the engine room.

MR. ALBERT GAY, M.I.E.E., asked by the President to speak, said that although the President was correct in saying that he was the author of a book upon the subject, he did not pretend to know very much about buildings. The buildings of the station he was connected with, although designed originally by himself, were completely directed by Mr. A. H. Tiltman, who must be held responsible for the thicknesses of walls, &c., which he did not pretend to know anything about. With regard to vibration, he thought that Islington, without taking any credit for it himself, had been absolutely free from any difficulty in that respect. When consulting with Mr. Tiltman about electric light buildings he (Mr. Gay) raised and most carefully considered the question of vibration, with the result that the whole of the foundations of the building were taken right down below those of the engines and plant. The foundations of the engines themselves were made, as Professor Kennedy mentioned, very wide at the bottom. They were practically monoliths, small at the top and widening out as the bottom was reached. The whole concrete foundation was erected on beach or ballast put into trays in the clay, with the result that the vibration was not transmitted in any direction to any material extent beyond the building itself. The wooden portion of the floor near to, or attached to, the foundation did, of course, vibrate slightly. One of the most serious difficulties they had had was in connection with three pumps erected almost adjacent to the church next door. The trouble was due partially to the suction pipes supplying the pumps passing through and being embedded in the wall. By putting in air vessels, and isolating this particular section, the difficulty had been practically overcome. With regard to air concussion and vibration, a good deal of difficulty had been experienced, but it had now practically ceased. For a time they used to exhaust into the air, and the result was that the doors and windows of the surrounding premises rattled a good deal, and the people in the church clergy house complained that they could get no rest at night. By putting the exhaust into the stack the difficulty, however, was largely minimised, and was now practically abolished altogether. Another difficulty was the transmission of noise or sound. The vibrations from the alternators seem to have the peculiar property of directing themselves in a given direction and spreading themselves in a very limited direction. In a certain part of the buildings adjoining intense noise had been experienced; yet by moving two or three inches away one could get almost out of its range. It seemed to be directed in a most peculiar fashion, without respect to any particular law. At any rate, the sound vibrations were the most important of all. That, however, was being got over, and he hoped would be successfully combated.

THE PRESIDENT, in putting the vote of thanks, said he was sure they were all glad that so many of these buildings had fallen into the hands of one who had proved himself so well able to meet the problems which had confronted him. They would also be pleased that architects were taking up these buildings; he could assure Professor Kennedy that architects were always glad to take up such buildings, for they were their *raison d'être* In this particular case there was a great architectural opportunity on account of the scale of the buildings, and the opportunity they afforded of plain wall surface. The chimneys, too, on account of their height and size, became a very important architectural feature. He had himself never been entrusted with one of these buildings, but they obviously offered great opportunities to the architect, and it must be a great pleasure for architects to work out a problem of this sort in collaboration with the engineers. It was essential from the very beginning that the engineer and the architect should work hand in hand and side by side. As Colonel Balfour had said, it had been for years the habit abroad for engineers and architects to work together, and almost all the bridges on the Continent were the work of engineers, architects, and sculptors. It had fallen to their lot at the Institute from time to time to impress upon their own local authorities that, when they had a great engineering work which was of such a position and character as to require architectural assistance, the best result would be obtained by associating the engineer and architect to work it out between them. He should like to echo

what had been already said with regard to Mr. Peach's drawings, and the modest way he had shown them to the Meeting. Only yesterday he happened to be passing the power station in St. John's Wood, and, although he would not say with Lord Wemyss that the chimney shaft was better than the Campanile of St. Mark's, still he thought it was a very fine chimney. Its great size, eighteen feet square inside at the top, made it an imposing structure, yet it looked like a chimney; and he thought that was much better than looking like the Campanile of St. Mark's. He thought it was a very useful hint of Mr. Peach's about the erection of chimneys. It was not necessary to go to very great expense in facing them with some extra good brick, which in London soon became black, but to vary it and have some other material in the upper portion, and so get the effect Mr. Peach had obtained in the station at St. John's Wood. The effect of those six chimneys in a row he thought would be very imposing, and the St. John's Wood people were doubtless looking forward to their completion! Whether it would add to the value of property around was not for him to say. Seriously, however, they had had a most interesting Paper, and they were much to be congratulated that this, almost the first Paper on the subject, should be read before the Royal Institute of British Architects. It would become, he was sure, a standard Paper, and one which would be referred to by those interested in such buildings. One thing that had struck him was the extraordinary rapidity with which the type of such buildings was being developed. Mr. Peach showed them the station in connection with the Tube (Central Railway). It seemed only the other day that the Tube was opened; but Mr. Peach spoke of it as an old-fashioned station now; so that electric science and the buildings to accommodate it were evidently advancing by leaps and bounds.

Mr. STANLEY PEACH, in responding, said that the cordiality with which the Meeting had passed the vote of thanks was particularly gratifying, as, by passing it in that way, he felt that they recognised the immense assistance and kindness he had received from architects and engineers, and the leading firms connected with the electrical industries in Europe, America, and England, in preparing the Paper. No one writing a paper could have received more assistance than he had, and when they came to read the Paper in the Journal, he thought they would find many matters dealt with which had been raised in the discussion. Every effort had been made to ensure the information being as accurate as possible, and it had in nearly every case been checked by the architects and engineers of the buildings described. The drawings on exhibition were in all cases original drawings lent by the architects or engineers who designed the buildings, and who had kindly supplied valuable information for the Paper. On the question of vibration raised during the discussion, Mr. Peach said that he had felt it was such a large subject that it would have taken an evening to go thoroughly into the various matters which arose in connection with it, and so he had not mentioned it in the abridged Paper which he had read, but it was dealt with to some extent in the Paper which would be printed. So far as aërial vibration was concerned, it could be overcome either by an expansion chamber on the exhaust pipe, or by a sufficiently large exhaust pipe carried up to a considerable height above the surrounding buildings. The matter rested practically with the engineers, and there was now very little difficulty from this cause. So far as the transmission of mechanical vibration through the foundations was concerned, this subject had been very carefully studied by those designing buildings of this class. A great number of measurements had been taken, and tests of various kinds had been made to see what steps could be taken to prevent it. Practically speaking, the best way to overcome the transmission of vibration was to put large enough foundations, as Professor Kennedy had described, and of sufficient width at the base. The foundations must also be rigid and heavy, and the load should be concentrated as far as possible at the edge of the engine block, rather than distributed in the centre. At the present time remarks on this subject should be taken rather as matters under consideration than authoritative statements based on well-ascertained and tested data. As regards the difficulty of expansion of the fire-brick lining of stacks. The lining of steel stacks is carried on angle irons, and is a comparatively simple matter, as space can be left at the top of each section under the angle iron carrying the next section to ensure room for the lining to expand; but in the case of brick shafts lined in a similar way to steel shafts, the fire-brick must be carried on in corbel courses, and it is very difficult to calculate or allow in the building the proper space for expansion, as there is considerable consolidation of the outer walls as the shaft is being built. Moreover, the fire-brick lining which is adopted in these cases is liable to bulge if not built tight up between the corbel courses, so that failure has resulted in several cases where an attempt has been made to apply the same principles of construction to brick as is used for steel shafts. The largest expansion he had ever measured in a fire-brick lining was nine inches in 100 feet; that was in the case of a stack which was cooled right down for some repairs to be carried out. The position which the top of the fire-brick lining had occupied while the stack was in work was clearly shown on the wall, so there could be no doubt about what the difference in length of the lining was between the stack hot and cold. In the Paper they would find a great

deal more information than he had given that evening, and if they had patience to read it he hoped they would find several points which would be generally useful not only for central stations, but in general practice.

LIST OF PLATES.

[*Inserted between pages* 308 *and* 309.]

PLATE

I. & II. Power Station of the Central Electric Supply Co. Ltd., Grove Road, St. John's Wood, London: Plan, elevation, and sections.

III. Power Station of the Underground Electric Railways of London, Ltd., Lot's Road, Chelsea: Plan and section.

IV. Power Station of the Corporation of Manchester, Stuart Street: General plans and sections.

V. Power Station of the Corporation of Dublin, Pigeon House Fort: Plan and section.

VI. & VII. Power House of the Third Avenue Railroad Co., Kingsbridge, New York: Plans, elevation, and sections.

VIII. & IX. Power Station of the Municipality of Vienna: Plan and section.

X. Berliner Electricitäts Werke, Ober-Spree, Berlin: Plan and section.

XI. & XI. A. Municipal Station at Amsterdam: Plan of building and section of foundations.

XII. Sub-station with Garden over of the Westminster Electric Supply Corporation, Duke Street, Mayfair, London: Geometrical drawings.

XIII. Sub-station No. 6 of the Manhattan Elevated Railways Co. of New York, and Sub-station of the Municipality of Vienna: Plans and sections.

XIV. Manchester Sub-station, and First Power Station of the Municipality of Geneva: Plans and sections.

XV. & XVI. Second Water Power Station of the Municipality of Geneva at Chèvres, and the Bennett Street Sub-station of the Manchester Corporation: Plans and sections.

XVII. Direct Supply Station of the County of London and Brush Provincial Electric Light Company, Ltd., City Road, London: Plan.

XVIII. Direct Supply Station of the Borough Council of Battersea, London: Plan and transverse section.

XIX. & XX. Composite Supply Station of the Corporation of Ipswich: Plan and section.

9, CONDUIT STREET, LONDON, W., 2*nd April* 1904.

CHRONICLE.

Special Elections to Fellowship.

The Council have elected the following gentlemen to Fellowship of the Institute under the proviso to By-law 9, viz.:—

JOHN KEPPIE, of 140 Bath Street, Glasgow, *President-Elect of the Glasgow Institute of Architects*, elected 14th March.

HENRY LANGTON GODDARD [*A.*], M.A.Oxon., of 8 Market Street, Leicester, *President-Elect of the Leicester and Leicestershire Society of Architects*, elected 28th March.

Photographic Competition.

Mr. Gilbert H. Lovegrove, Hon. Sec. A.A. Camera and Cycling Club, asks notification in the JOURNAL of a photographic competition, open to members of the architectural profession, to be held under the auspices of the Club. The following are the rules:

1. The competition is confined to sets of photographs adapted for the purpose of architectural study.

2. The competition is open to members of the architectural profession, and all members of the Architectural Association.

3. Each set should consist of not more than twelve prints, and illustrate one subject or class of subjects.

4. A competitor may submit any number of sets.

5. The whole of the work in connection with the photographs submitted must have been carried out by the competitor.

6. Photographs must be sent to the Secretary of the Architectural Association Camera and Cycling Club, at the offices of the Architectural Association, not later than the 1st October, and must be mounted, but not framed.

7. The photographs will be approved by the Committee of the Architectural Association Camera and Cycling Club as having reached a fair standard of technical excellence, and will then be finally adjudged by a gentleman, not a photographer, who is an expert in architectural tuition, and who will be chosen by the President of the Architectural Association. Such name to be declared before the end of March.

8. Copies of the winning prints, by a permanent process, must be deposited with the Architectural Association before the prize is presented to the winner.

9. The Architectural Association and the Architectural

Association Camera and Cycling Club will not be responsible for any loss or damage to any prints entered for the competition, nor for any charges for carriage, &c.

10. A prize value three guineas will be awarded to the best set of prints, and will take the form of books or apparatus.

Mr. E. Guy Dawber [*F.*] is to be judge.

House of Commons Committee on Ventilation.

A series of articles from the *Building News*, purporting to be an analysis of the Report of the Select Committee on the Ventilation of the House of Commons, has been published in pamphlet form [Hickson, Ward & Co., Chiswell Street, E.C.: price 1*s.*]. The Select Committee consisted of Sir Michael Foster, F.R.S., *Chairman*, Sir J. Batty Tuke, M.D., Messrs. Robert Farquharson, M.D., Victor Cavendish, John Dillon, D. F. Goddard, and A. H. Smith. The pamphlet may be seen in the Library.

The late John Gibson.

The bust of the late John Gibson, kindly presented to the Institute by Mr. William Glover [*F.*], has been placed in the lobby at the foot of the staircase leading to the Library. The bust was modelled by the late Mr. Bursill, a Royal Academy Medallist and Travelling Student, who executed the bronze statues on Holborn Viaduct, and the figures and panels at the National Provincial Bank in Bishopsgate Street.

John Gibson [*b.* 1817, *d.* 1893] was elected Associate of the Institute in 1849 and Fellow in 1853. He served for many years on the Council and as Vice-President, and received the Royal Gold Medal for Architecture in 1890. He was a pupil of Sir Charles Barry, and on the completion of his articles remained with him as assistant for some years, his work being almost exclusively confined to the drawings and works connected with the Houses of Parliament. Commencing practice in 1844 he won his first success in the competition for the buildings of the National Bank of Scotland at Glasgow. Others of his early works were the Imperial Fire and Life Office, Threadneedle Street; the twin-spired Romanesque Chapel in Bloomsbury, erected in 1847; the Imperial Insurance Company's office at the corner of Old Broad Street; several buildings in Warwickshire, such as Compton Verney, for Lord Willoughby de Broke; Wroxton Abbey; Charlecote Park; Guy's Cliff, and several churches. Bodelwyddan Church, erected in 1860 for Lord Willoughby de Broke, was considered the finest of Gibson's ecclesiastical works. In 1864 he was appointed architect to the National Provincial Bank of England, and built for it the head office in Threadneedle Street, the branch bank in Piccadilly, and upwards of forty other branches in different parts of the country. Other notable London buildings of his were Child's Bank in Fleet Street, and the premises of the Society for Promoting Christian Knowledge, the first building erected in Northumberland Avenue.

Bust of John Gibson [*F.*], Royal Gold Medallist 1890, modelled by H. Bursill and executed by John Underwood in 1868.

Presented to the Council in 1904 by William Glover [*F.*], Past President of the Northern Architectural Association.

The Coal Smoke Abatement Society.

At the annual general meeting of this Society, held on Tuesday, 22nd ult., the Chairman, Sir William Richmond, K.C.B., R.A., in proposing the adoption of the report, said that the amount of work done by the Society in the past year was very considerable. From 1st January to 31st December the Society's inspector reported 2,000 observations of smoke pollution, which led to the detection of 1,460 cases of nuisance, and upon those observations 1,278 complaints were forwarded to the various metropolitan local authorities. Following those complaints forty summonses were issued under the Act, involving the offending firms in penalties and costs. The Committee had been able to draw up a list of sixty-eight firms who, before the Society exerted and made itself felt, habitually polluted the atmosphere of our city with one or more chimneys, and whose works within the past six months had not been observed to emit any smoke at all. Considering that all this work had been done with only one inspector, it might be taken as a great achievement. Before the Society was founded none of the London boroughs paid any attention to the clause in the Public Health Act relating to pollution of the atmosphere by smoke. The London County Council took no action in the matter, and the borough councils refused to obey the law. When the Society was started it was determined to proceed in the simplest way, and, instead of trying to frame a new law, to try and get the existing law put into operation. They were now in co-operation with almost all the borough councils in London and with the London County Council, and at the instance of the Society the latter body was meditating a most desirable scheme, viz. to fine offenders £10 for the first offence, the fine to be doubled on a recurrence of the nuisance. The City of Westminster was in harmony with the desires of the Society, and he was pleased to find that they were able to prosecute clubs for emitting black smoke. West Ham was a very great factor in the smoke nuisance question; the sanitary authorities of that place had been very remiss in the performance of their duties, and although they had received from the Society 572 observations, the borough councils had refused to act. The Society were now taking the matter into stronger hands, and had appealed to the Local Government Board to perform the duties which the borough councils ought to do. With regard to domestic grates, there was no doubt that they could get rid of the smoke from that source if they chose, but the Society would rather press the question of the manufacturer first.

The report having been adopted, the following resolutions were passed:—

"That the pollution of the air by coal smoke is injurious to public health and vitality, destructive to works of art and vegetation, and directly demoralising to the inhabitants of a great city."

"That this meeting, in recognising the practical results already achieved by the Coal Smoke Abatement Society with the limited resources at its disposal, and in approving of its line of action, pledges itself to use its best endeavours to place it in a position to extend its operations."

An Architect's Memorial.

From Mr. Henry Lovegrove [*A.*]—

In the Parish Church of St. Mary, Islington, now being altered by Sir Arthur Blomfield & Sons, many of the old memorial tablets are being refixed. At the East end of the South gallery a tablet ornamented by a T square and plumb rule bears the inscription:

In Memory of
Mr. Lancelot Dowbiggin
Citizen and Joiner of London
Died July 24th, 1759, aged 70 Years.
Architect to this Church
in the year 1754.

THE REGISTRATION OF ARCHITECTS.

46, *Lincoln's Inn Fields, London, W.C.,*
22nd March 1904.

To the Editor of the Journal of the Royal Institute of British Architects,—

Sir,—Professor Beresford Pite's lecture on this subject published in the Journal of the 5th March contains the best definition of the art of architecture with which I am acquainted. If, however, his deductions therefrom are sound the Institute principle of compulsory examinations for membership and its system of examinations stand condemned and should at once be swept away. It is for the members, and especially for the Associate members, to say whether they are prepared to regard the Professor's logic as irrefragable, and further whether, in that case, it is expedient to take so retrograde a step.

As regards his assumption that until some other Bill is before the Institute that drafted by the Registration Act Committee many years ago must form the basis of the discussion of the R.I.B.A. Registration Committee as to the practicability of the statutory training of architects, we would observe, first, that the main principles of a Registration Act have been conceded by, and have governed, the procedure of the Institute for many years; and, secondly, that provided a majority of the members desire the maintenance of these principles and their extension to the profession generally, it becomes the imperative duty of the Institute Council to draft a new Bill which, while avoiding any points in the existing Bill they may consider detrimental, either to the art of archi-

tecture, to the profession, or to the interests of the public, will best secure the end aimed at, viz. the adequate education of all architects and the penalising of unqualified and unworthy practitioners, and will safeguard the various interests involved.

The remaining arguments of Professor Pite's lecture appear to resolve themselves into this, namely, that it is impossible to qualify a man by any system of education to practise architecture because the only test of an architect's qualification is his executed work!

As regards the structural side of architecture he urges that it is not proposed to test civil engineers, forgetting apparently that the Institution of Civil Engineers comprises practically all practitioners of any standing, and is closed by a very severe scientific examination.

His contention that the attempt to test a man's knowledge of building construction, his skill in draughtsmanship, and capacity to design will lower the ultimate standard of professional attainment can only be made good by undeniable evidence that the qualifications of the Associate members of the Institute are lower than they would have been had they not been obliged to pass the examinations.

The advocates of registration have never overlooked the interests of architecture as a fine art. It only remains to reply to the assertion that in all such subjects as history, ornament, and design it is inevitable that the sanction of penalties should involve the easing of the standard of education, and that we cannot afford to encourage lax training at the present time. We ask, can any instance be quoted in which the system of compulsory qualification has led to the lowering of the standard of education? The contrary has invariably occurred.

The present examinations of the Institute are a compromise between the voluntary and the compulsory systems, and like most compromises they fail to effect the desired end of educating the profession generally.—Yours faithfully,

W. H. Seth-Smith.

REVIEWS.

ST. PATRICK'S, DUBLIN.

The Cathedral Church of St. Patrick. A History and Description of the Building, with a short Account of the Deans. By J. H. Bernard, D.D., Dean of St. Patrick's. Price 1s. 6d. *[London: George Bell & Sons,* 1903].

From the "Land of the Saints" has come the latest addition to Bell's Cathedral Series, in a most admirably concise and interesting history of St. Patrick's Cathedral, Dublin. It is a work which will commend itself, not merely as a convenient handbook to the casual visitor, but as an historical record it will be of considerable value to the archæologist and architect. In his prefatory note, the author, Dean Bernard, refers to an extant work on the same subject which, though indispensable to the historian, he considers of little use to the student of architecture, as the writer had no special knowledge of that subject. Dean Bernard has had the wisdom, therefore, in the preparation of the present work, to seek the assistance of the cathedral architect, Sir Thomas Drew, to whom is probably due much of the interesting and detailed description which the book contains of the many vicissitudes through which the fabric passed from its earliest history to its restoration by the beneficence of the Guinness family.

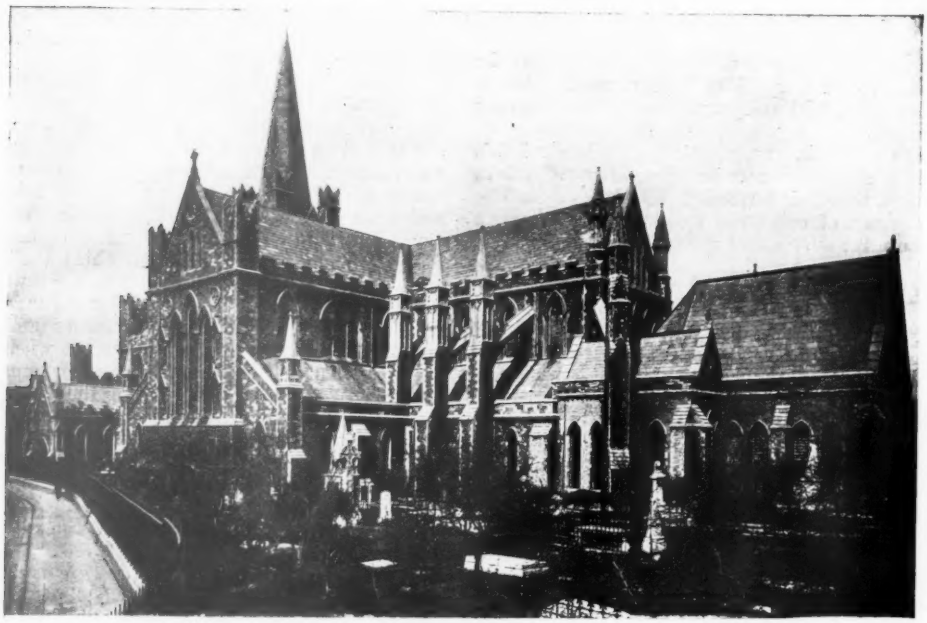
The author is evidently quite at home with his subject, which he has treated with the sympathy befitting an Irishman when writing the history of a church so intimately associated with memories of the national tutelary saint. The exact site of the well in which that saint baptised the people on his first coming to Dublin has, according to Dean Bernard, "been determined to a high degree of probability"; and a stone, marked with an ancient Celtic cross, has been discovered close to the north-west corner of the nave; concerning which it is stated "that there is no reasonable cause for doubting that this stone originally stood over St. Patrick's Well, and that it dates from the ninth or tenth century at latest."

To the peculiar sanctity in which this site was held, by virtue of its association with the name of St. Patrick, is ascribed its selection for the cathedral building. The choice would appear to have been a most unfortunate one, for it was on the marshes of the Poddle River, and "all through its history the lack of a crypt and the moist clay of the foundations, through which springs continually flow, have been injurious to the fabric."

The exterior of the cathedral and its precincts, as well as the interior as it at present exists, are described in considerable detail, and some interesting information is given in the chapter on the "Historical Memorials" concerning notable services which have been held in the cathedral. One such took place on the 27th January 1660, to inaugurate the Restoration, at which twelve bishops were consecrated by Archbishop Bramhall, the sermon being preached by Jeremy Taylor, Bishop-elect of Down and Connor. The anthem was composed by the Dean (Fuller), the chorus being as follows:—

> Angels, look down, and joy to see,
> Like that above, a monarchie.
> Angels, look down, and joy to see,
> Like that above, an hierarchie.

There are naturally many allusions throughout the book to Jonathan Swift, the most famous of the deans of St. Patrick's. His pulpit still stands in the nave of the cathedral, his bust is close to the door leading to the robing-room, and his opinions con-



ST. PATRICK'S CATHEDRAL, DUBLIN.

cerning some of his predecessors are inscribed in vigorous but decidedly unparliamentary language on more than one lease preserved in the archives. Across a lease, for instance, issued in the name of one Bassenet (a namesake of a former dean) Swift has written that he "was kin to that scoundrel who surrendered the deanery to that beast Henry VIII."

As a record of careful and intelligent restoration, the book will be appreciated by all students of architecture. It is of convenient size, and is profusely illustrated by excellent reproductions from sketches and photographs.

Dublin. FREDERICK BATCHELOR.

BRICKWORK AND MASONRY.

Brickwork and Masonry. A Practical Text-book for Students and those engaged in the Design and Execution of Structures in Brick and Stone. By C. F. Mitchell and G. A. Mitchell. 8o. *Lond.* 1904. [*B. T. Batsford, 94 High Holborn.*]

As the authors point out in the preface, "much of the subject-matter is contained in their works on building construction; but it has here been correlated, revised, and extended." The branches more fully dealt with in this volume are: retaining walls, domes and vaulting, arches and bridges.

In *Brickwork*, besides the usual notes on foundations, bonding, and the construction of flues, special articles are devoted to the construction of tall chimneys and brick sewers. In *Masonry* all the technical terms are explained, and the various methods of building and dressing stonework carefully defined.

In addition to these subjects, special chapters are devoted to concrete, limes, and cement, and the methods of measuring excavators', bricklayers', and masons' work are generally dealt with. The various kinds of brick and stone generally used are classified and their characteristics given.

The authors give tables of safe loads, strength and weight of materials, thicknesses of walls, &c., which will be found useful, also various examination questions which have been set by different authorities during recent years, and the volume is well illustrated by numerous diagrams and details. It is a book which will prove of great assistance to the student in building construction.

F. DARE CLAPHAM.

ALLIED SOCIETIES.

THE GLASGOW INSTITUTE.

Dinner to Mr. J. Honeyman, LL.D., R.S.A.

On 10th March, at the Grosvenor Hotel, Gordon Street, members of the Glasgow Institute gave a complimentary dinner to Mr. John Honeyman, R.S.A., in testimony of their appreciation of his half-century of professional life. Besides members of the Institute there were present Mr. W. I.

Blain, the President of the Glasgow Architectural Association, Mr. F. H. Newbery, head master of the Glasgow School of Art, and Mr. Crawford, the President of the Glasgow Art Club.

In proposing the toast of the evening the President, Mr. Horatio K. Bromhead [*F.*], said that never had honour been more deserved by any Glasgow architect, and they had great pleasure in thus conveying to him their congratulations on his jubilee of fifty years' practice on his own account in Glasgow. Mr. Honeyman commenced practice in 1854, and he (the President) could testify to the great kindness which he personally received from him. It would be pleasant to refer to Mr. Honeyman's numerous works, but he would only touch lightly upon one or two. No one with knowledge could look upon Brechin Cathedral without being impressed with the delightful combination of profound knowledge and exquisite care and judgment displayed in its restoration. Nor could the student fail to delight in the beauties of Skipness Castle, or help being struck with admiration at the superb manner in which every detail had been supervised by one who revelled in the chaste loveliness of Scottish baronial architecture. These two examples were characteristic of the common sense which marked all his work. Avoiding the endeavour to be too original, he never went to the other extreme of dull monotony and of slavishly copying existing works. Amid his professional work Mr. Honeyman found time for archæology, and was prominent in connection with the formation of the Archæological Society in 1855. In the early years of his (Mr. Bromhead's) connection with the R.I.B.A. it was seldom convenient to attend the meetings in London, and he considered himself fortunate in being present at a meeting in 1874, and hearing the President, the late Sir Gilbert Scott, the architect of Glasgow University, say how pleased they were at having in Mr. Honeyman a second member from Glasgow and a fourth from Scotland joining the Institute. The R.I.B.A. had now 68 members in Scotland. In 1876 Mr. Honeyman was elected a member of the Council of the R.I.B.A., and was re-elected in 1878 and 1884. He was one of the original members of the Glasgow Institute of Architects, and held the office of a member of Council in 1869 and 1870, and from 1874 to 1883. He was Vice-President from 1876 to 1878, and President in 1881 and 1882. In 1889 he retired from the Glasgow Institute, and in 1900 was elected an honorary member.

Mr. Campbell Douglas [*F.*] and Mr. Keppie [*F.*] also spoke to the toast, which was received with great enthusiasm.

Mr. Honeyman, in replying, expressed the difficulty he felt in finding suitable words to acknowledge the enormous kindness which had been exhibited towards him. In referring to the very limited means of architectural training that existed in his earlier years, and to his having studied in London before he commenced in Glasgow, he said that he had always been deeply interested in the educational schemes of the R.I.B.A.; and while he approved of the examination for Associates, he also believed in a discretionary power, on the part of the Council of the Institute, in the election of Fellows.

LEEDS AND YORKSHIRE SOCIETY.

The Retiring President's Address.

The last meeting of the session was held in the Society's rooms on March 24th, Mr. Butler Wilson [*F.*] presiding. The officers and council elected for the ensuing year were as follows:—President, Mr. G. Bertram Bulmer [*F.*]; Vice-Presidents, Mr. H. S. Chorley [*A.*] and Mr. W. G. Smithson [*A.*]; Hon. Secretary, Mr. Robert P. Oglesby; Hon. Treasurer, Mr. W. H. Thorp [*F.*]; Hon. Librarian, Mr. G. F. Bowman; Council, Mr. R. Wood, Mr. C. B. Howdill [*A.*], Mr. Percy Robinson, Mr. T. E. Marshall (Harrogate), Mr. F. Musto [*A.*], and Mr. G. E. Reason (Associate Member).

At the conclusion of the business, the retiring President, Mr. Butler Wilson, in addressing the meeting, said:—GENTLEMEN,—After occupying this chair for three successive years, I take occasion at this our last sessional meeting to tender my best thanks to the officers and council not only for their great kindness to me but also for the ever-ready help and assistance which they have accorded to me in the conduct of the affairs of this society. Events of considerable importance both to this city and to the profession generally have been dealt with by them, and their time and labour have been given to these objects with an unsparing hand. I feel confident that my successor, Mr. Bulmer, will receive the same hearty support in his duties that it has been my happy lot to experience. He filled the office of president in former years, and the efficient manner in which his duties were then exercised is sufficient guarantee that he will bring to bear upon his renewed responsibilities the same energy and ability which he then displayed. It is matter for congratulation that he is a staunch supporter of statutory qualification under the auspices of the Royal Institute of British Architects. As you know, I had the honour in January last to give notice that I should move certain resolutions bearing upon this question, and I was supported at the Institute on that occasion by a number of Presidents of Allied Societies. A careful estimate of the composition of the meeting was made by metropolitan supporters of the movement, and I was assured that there was not present the two-thirds majority necessary to carry the first resolution, which was of an uncompromising character, viz.: "That this Institute is in favour of the statutory registration of qualified architects." I determined,

therefore, to withdraw the first resolution as above, but not before I had a definite and authoritative assurance that my second resolution, to appoint a committee, would be permitted to go forward in the form of an amendment. This was done, but as Mr. Macvicar Anderson proposed a further amendment, which, as a matter of fact, gave me even better terms, viz. that all the Allied Societies should be represented on the committee, I at once withdrew in his favour. That committee, formed on the motion of a past-president, has now met and consists of an equal number of metropolitan and provincial members. My action in withdrawing my first motion has thus been completely justified by the very satisfactory result obtained. Had the first motion been put to the meeting and defeated, the accomplishment of our object might have been postponed for some years. I had in my mind what occurred at the Institute thirteen years ago when a similarly blunt resolution was persisted in with disastrous results. This piece of history I did not wish repeated. As showing the trend of professional feeling, it gives us great pleasure to know that an architect whose work we all admire, Mr. Guy Dawber, President-elect of the Architectural Association, has become a supporter of this movement. Moreover, an independent committee of London members of the Institute has recently been formed, with statutory qualification as its object, and contains names which traverse the idea, which it has been attempted to put forward, that the movement wins no sympathy from the æsthetic element within our profession.

On the motion of Mr. G. F. Bowman, seconded by Mr. G. Bertram Bulmer [*F.*], President-elect, and supported by Mr. W. H. Thorp [*F.*] and others, a high tribute was paid to Mr. Butler Wilson for the admirable work he had accomplished during his three years' presidency, together with an appreciation of his energy and zeal in the cause of the affairs of the Society. Mr. H. S. Chorley [*A.*], the retiring Honorary Secretary, was also complimented upon his efficient conduct of an onerous position on the motion of Mr. Robert P. Oglesby.

Mr. Starkie Gardner then read a Paper on "Architecture in Lead," which was much appreciated by the members.

THE NORTHERN ASSOCIATION.

Annual Report.

The Annual Report for the Forty-fifth Session states that there are sixty-nine members, seventy-two Associates, and seventy-eight students, or 219 in all, an increase of sixteen during the year. The report sets out in full the trust deed for the administration of the sum of £1,500 presented to the Association by Mr. Wm. Glover. The money is invested, and Mr. J. Walton Taylor, *President*, and Mr. A. B. Plummer, *Hon. Secretary*, have consented to act as trustees. The income of £1,000 is to be applied for the educational work of the Association. It is proposed to found a Travelling Studentship, to be called the "Glover Travelling Studentship," and to institute a Medal, to be called the "Glover Medal" and to be awarded to student members for works of exceptional merit; prizes, fees for lectures, and additions to the Library are also proposed. The deed provides for the investment of the remaining £500 and accumulation of interest with the ultimate object of acquiring permanent offices for the Association. The question of borough surveyors carrying out architectural work has been under consideration by the Council, and Mr. A. B. Plummer endeavoured to ascertain what was thought by other societies on the subject. It was found that in some cases borough engineers have architects under them in their offices. The Sheffield Society stated that they have been able to influence their City Council to some extent against a similar state of affairs. In Leeds work of an architectural character is not so often entrusted to the city engineer as formerly. The Town Council of Leicester have resolved to put all works costing more than £500 into the hands of architects. In some rural districts the district engineers and surveyors not only carry out architects' work for the district councils, but they are allowed "private practice," and have, therefore, practically to recommend their Councils to pass their own plans, and other architects are placed at a disadvantage with those who would otherwise be their clients. The grievance was brought under the notice of the R.I.B.A. Council, and the reply was that a large committee had been formed, including all the Presidents of Allied Societies, to go thoroughly into the question.

MINUTES. XI.

At the Eleventh General Meeting (Ordinary) of the Session 1903–04, held Monday, 28th March 1904, at 8 p.m.—Present: Mr. Aston Webb, R.A., F.S.A., *President*, in the chair, 36 Fellows (including 11 members of the Council), 42 Associates (including 2 members of the Council), and numerous visitors: the Minutes of the Meeting held 14th March 1904 [p. 277] were taken as read and signed as correct.

The following members attending for the first time since their election were formally admitted by the President—viz. Arthur Benjamin Plummer (Newcastle-on-Tyne) and Arthur Keen, *Fellows*; Henry Arthur Battley, Horace William Cubitt, William Robert Davidge, Harold Griffiths, Henry Blinman Mackenzie, *Associates*.

A Paper by Mr. Charles Stanley Peach [*F.*], entitled NOTES ON THE DESIGN AND CONSTRUCTION OF BUILDINGS CONNECTED WITH THE GENERATION AND SUPPLY OF ELECTRICITY KNOWN AS CENTRAL STATIONS, having been read by the author and illustrated by lantern views and by plans and working drawings of the buildings referred to, a discussion ensued, and a vote of thanks was passed to Mr. Peach by acclamation.

The proceedings then closed, and the Meeting separated at 10 p.m.